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ABSTRACT

This Oklahoma curriculum guide, which includes a teacher edition, a student edition, and a student workbook, provides three units for a course on oxyacetylene welding, oxyfuel cutting, and cutting done with alternative fuels such as MAPP, propane, and natural gas. The three units are: "Oxyacetylene Welding"; "Oxyfuel Cutting"; and "Oxyacetylene Braze Welding and Surfacing." The teacher edition consists of introductory pages and teacher pages. Introductory pages include a training and competency profile, a national skills/Oklahoma duty and task crosswalk, an instructor task analysis, basic skills icons and classifications, a basic skills matrix, and a list of tools, equipment, and materials needed. Teacher pages include suggested activities, answers to assignment sheets, written test with answers, teacher supplements, and transparency masters. The student edition includes learning activities sheets, objective sheets, information sheets, and student supplements for each unit. The student workbook contains assignment and job sheets (skill tests) keyed to the objectives of each unit. (KC)

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ED 467 876

Oxyacetylene Welding and Oxyfuel Cutting. Third Edition. Teacher Edition [and] Student Edition [and] Student Workbook.

John Knapp

Eddie Harper

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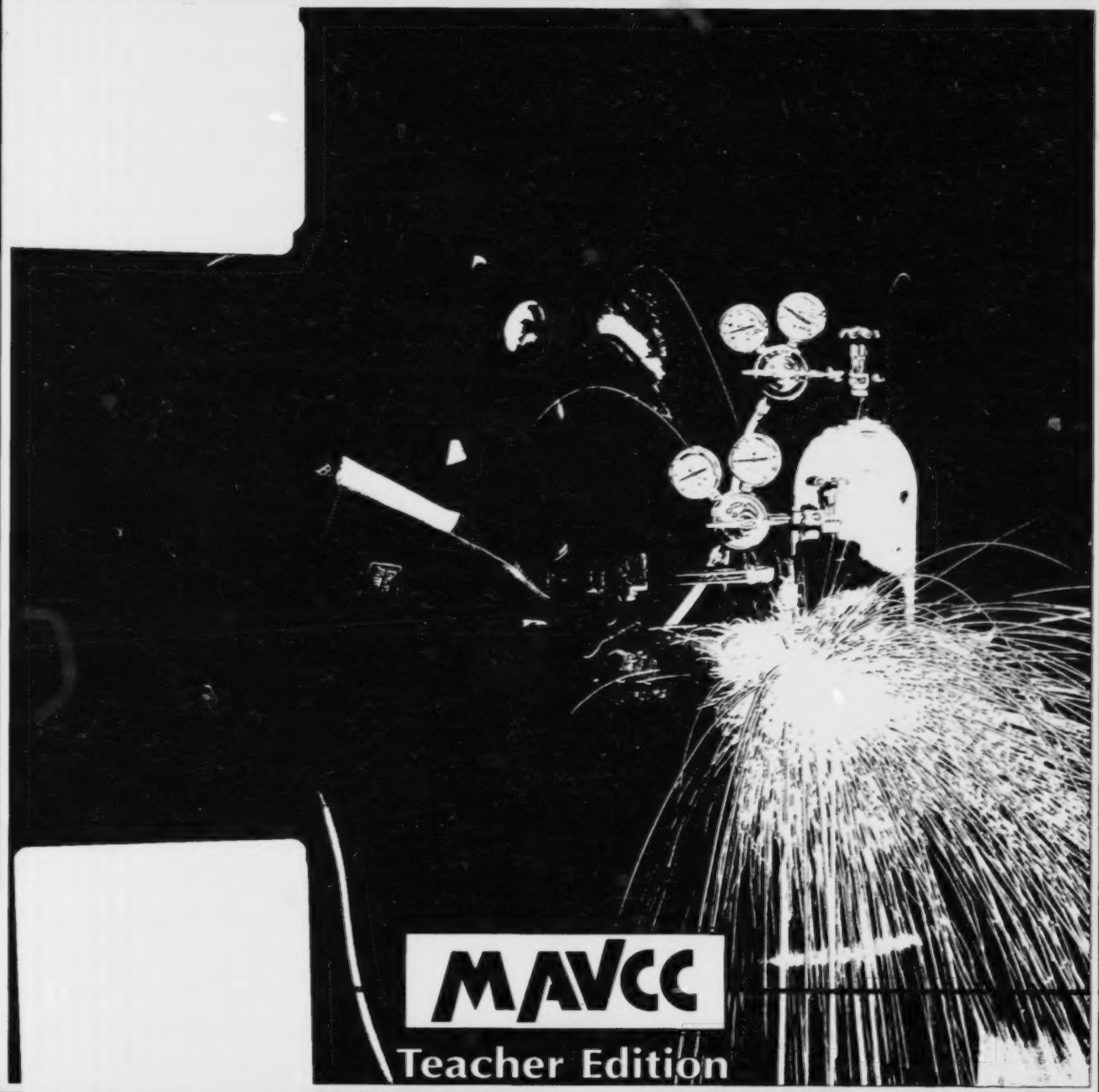
THIRD EDITION



MAVCC

Teacher Edition

CE 083 646

02-015633

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Oxyacetylene Welding and Oxyfuel Cutting

Teacher Edition

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Units of Instruction

Unit 1: Oxyacetylene Welding

Unit 2: Oxyfuel Cutting

Unit 3: Oxyacetylene Braze Welding and Surfacing

Foreword

This revised text retains the original Unit 1, "Oxyacetylene Welding", because of its varied applications in many kinds of welding shops, on farms, and in auto repair shops. In short, oxyacetylene welding is still a needed skill in the workplace.

Unit 2 is not titled, "Oxyfuel Cutting" because it contains not only oxyacetylene materials, but much new information about the alternate fuels used in oxyfuel cutting and heating. Because of their convenience and economy, fuels like MAPP®, propane, and natural gas are changing the nature of many cutting and heating jobs. Along with alternate fuels, there is new information about liquid oxygen and its use in the welding workplace. And with the expanding use of alternate fuels comes new equipment, torches and tips especially designed to promote convenience and economy in alternate fuel applications. There's also a new job sheet in Unit 2 to introduce students to new procedures for lighting and adjusting an alternate fuel flame.

Unit 3, "Oxyacetylene Braze Welding and Surfacing" rounds out this revised edition to offer a text that covers the broad range of oxyfuel applications whose portability continues to make them an essential part of the world of welding.

This Third Edition of *Oxyacetylene Welding and Oxyfuel Cutting* includes a Student Workbook that contains assignment sheets and job sheets for Units 1, 2, 3. Student Workbooks can be purchased individually each year to help keep curriculum expenses at a minimum and still provide students with updated materials needed to complete the course.

MAVCC's complete welding series is crosswalked to the state of Oklahoma's Welding Duty/Task list which is aligned with AWS standards.

Kimberly Sadler, Chair
Board of Directors
Multistate Academic and
Vocational Curriculum
Consortium

Jane Huston
Executive Director
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Vocational Curriculum
Consortium

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Well deserved thanks go to the many industry and education representatives who participated as members of MAVCC's welding committees through the years. Their assistance in developing and revising these instructional materials has been an essential step in MAVCC's development process.

Appreciation is extended to those individuals who contributed their time and talent to the third revision of *Oxyacetylene Welding and Oxyfuel Cutting.*

Paul Childers	Choctaw, OK
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John Knapp	Tulsa, OK
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Owen Smith III	Tulsa, OK
Terry Smith	Wichita, KS
Luke Steinmetz	Rapid City, SD
Gary Watts	Waverly, TN

We would also like to acknowledge the manufacturers and suppliers whose procedures and graphic materials have helped enhance this text. Special thanks go to the American Welding Society, Harris Calorific, Inc., the H&M Pipe Beveling Company, and to the Lincoln Electric Company.

Special appreciation is extended to Rick Lomenick, electronic publishing technician, for his assistance in scanning artwork and formatting units of instruction for this project.

Appreciation is also extended to the employees of the Graphics Division of the Oklahoma Department of Career and Technology Education for printing this publication.

Thanks are also extended to Dan Fulkerson, Project Coordinator, and to Jane Huston, MAVCC Executive Director.

Use of This Publication

Oxyacetylene Welding and Oxyfuel Cutting is available in both a teacher and student edition. The contents of these materials are tied to measurable and observable learning outcomes that were identified and validated by the welding advisory committee, comprised of business/industry representatives and teachers. Competencies align with the welding duty/task list developed by the state of Oklahoma.

Teacher Edition

The complete teacher edition consists of introductory pages and teacher pages. It is recommended that the instructor purchase the student edition and student workbook for a complete teacher edition. The introductory and teacher pages are loose-leaf and three-hole punched. The student edition is spiral-bound, and the student workbook is perfect-bound with the pages perforated for easy removal. Each are divided into units of instruction that may be broken into more than one lesson or class period. For added flexibility, each unit in the teacher edition is individually numbered beginning with a T for teacher page, followed by the unit number and page number.

Example:

Page 17 of Unit 3 in the teacher pages are represented as T 3–17.

MAVCC—*Oxyacetylene Welding and Oxyfuel Cutting*	T 3–17

Pages in the student workbook are numbered sequentially beginning with page 1.

MAVCC *Oxyacetylene Welding and Oxyfuel Cutting*	Page 1

Pages in the student edition are numbered beginning with the unit number, followed by the page number.

Example:

Page 7 of Unit 5 in the student edition is represented as Page 5–7.

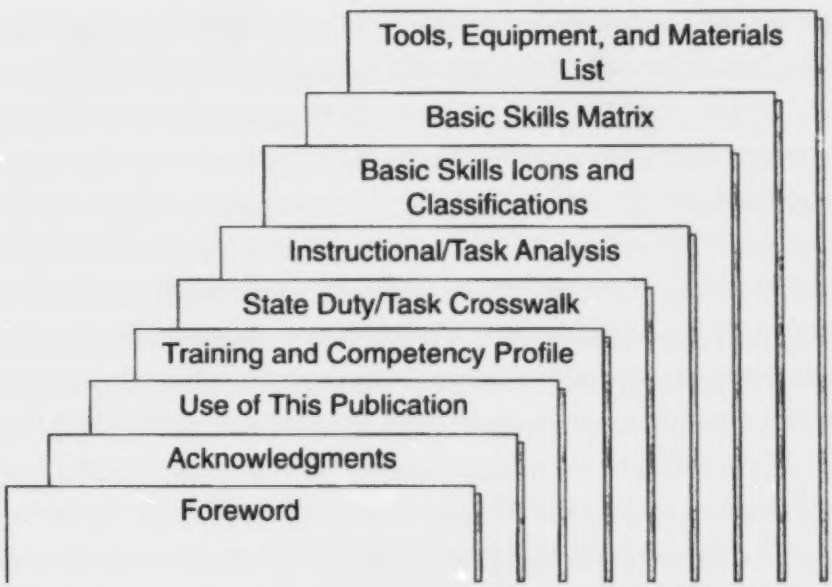
MAVCC *Oxyacetylene Welding and Oxyfuel Cutting*	Page 5—7

For group instruction, the teacher should determine the best way to teach each objective and allow for student participation. For self-paced or individualized instruction, students should be provided with opportunities to become involved in planning and being responsible for their own education. Careful study of each unit of instruction by the teacher will help to determine the following:

- amount of material that can be covered in each class period;
- supplies and materials required for assignment sheets and job sheets;
- resource people who must be contacted;
- supplementary materials to be ordered;
- skills that must be demonstrated and the amount of class time needed for demonstrations; and
- amount of class time needed for student practice and return demonstrations of mastered skills.

Teachers are encouraged to localize and personalize these materials to meet the needs of individual students, the community, and prospective employers.

Introductory Pages



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In addition to general information, such as the table of contents, acknowledgments, and the use of this publication, the following tools have been provided to assist administrators and teachers in planning for instruction.

- **Training and Competency Profile.** This form may be copied and used to record information about each student, such as enrollment dates, class attendance, and work experience, and to document the student's mastery of specific job competencies. It can also be used to provide information about the student's qualifications to potential employers and/or for entry into advanced training programs.

- **National Skills and/or State Duty/Task Crosswalk.** This document identifies the national and/or state skill standards covered in this publication and lists specifically where these skills are located by unit number and objective.

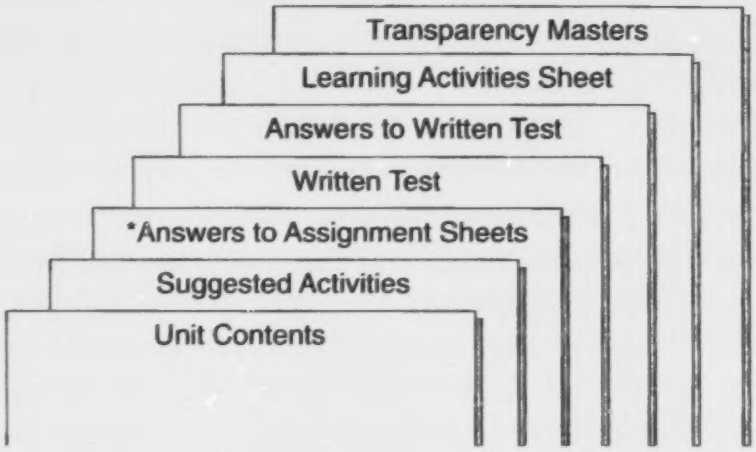
- **Instructional/Task Analysis.** This document provides a quick review of the contents of this publication by identifying the cognitive skills (what the student should know) and psychomotor skills (what the student should be able to do) addressed in each unit of instruction.

- **Basic Skills Icons and Classifications.** This page provides a reference guide of the graphic symbols that are used to identify the basic academic and workplace skills included in each focus assignment, assignment sheet, and job sheet.

- **Basic Skills Matrix.** This document graphically summarizes the academic and workplace skills training included in the instructional materials, unit by unit. It should be helpful to teachers in planning for instruction, and to administrators as documentation that basic skills are being taught as part of the vocational training.

- **Tools, Equipment, and Materials List.** This document provides a comprehensive list of those items needed in a vocational program for students to complete training. It also can assist administrators and teachers in determining program costs.

Teacher Pages



*Designates components that may not appear in every unit of instruction

Teachers should study the teacher and student pages before introducing the unit, allowing enough time to obtain supplemental materials and to contact outside resource persons.

- **Suggested Activities.** This component assists teachers during the preparation stage of the teaching/learning process by providing an instructional plan, teaching suggestions, a list of references used in the development of each unit, and a list of suggested supplemental resources (books, posters, pamphlets, videotapes, computer software, and Internet sites) that may be used to enhance instruction.

  Instructions for evaluating student performance on the assignment sheets and job sheets are also included in the suggested activities section. Teachers should select and discuss with students the rating scale that will be used.

- **Answers to Assignment Sheets.** An answer key is provided, when applicable, to assist the teacher in evaluating student performance on a given assignment.

- **Written Test.** This component provides criterion-referenced evaluation of every cognitive objective listed in the unit of instruction, and serves as both a pretest and posttest to assist teachers in measuring each student's competency gains. (Assignment sheet and job sheet objectives are not evaluated on the written test.) If the teacher has added, deleted, or modified any objectives, appropriate changes should be made to both the test and answers to the written test.

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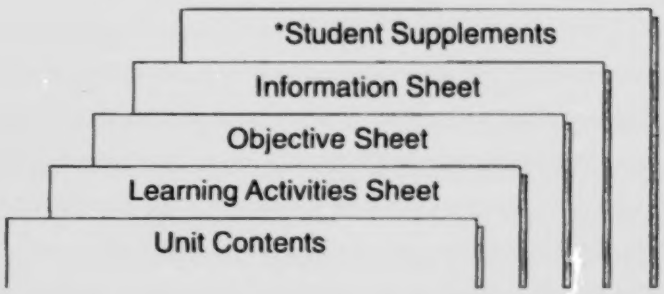
Tests may be divided into shorter tests covering three or four objectives at a time and given soon after those objectives have been covered. A selection of test items from the units covered may be used for a final test at the end of each term if desired. The written test is included in the teacher edition only and should be duplicated for student use.

- **Answers to Written Test.** An answer key is provided to assist the teacher in evaluating student performance on the written test.

- **Teacher Supplements.** These are optional materials for the teacher to use. They have three purposes: to provide the teacher with higher-level materials to stretch the advanced student; with remedial information or practice to assist the less-advanced student; and with state-of-the-art information in which the teacher may not have a background or with information that is not readily available in other books. Some teacher supplements may be duplicated for student use and are marked accordingly.

- **Transparency Masters.** These overheads are used to direct the students' attention to the topic of classroom discussion. Transparencies allow the student to see as well as hear the information being presented, thus reinforcing the learning process. They may provide illustrations, charts, schematics, or additional information needed to clarify and reinforce objectives included in the unit of instruction. Some of these items may also appear with the appropriate objectives in the information sheet in the student edition. The teacher may make acetate copies from the masters or, in most cases, complete transparency sets are available for purchase.

Student Edition



*Designates components that may not appear in every unit of instruction

For best results, students should be provided with a copy of the student edition and should be allowed to take notes in the margins as additional information is provided by the instructor or as the student acquires additional information through library or Internet research.

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- **Learning Activities Sheet.** This component provides a model for teachers to use in implementing a self-paced or individualized program, and guides the student through the required components in the student edition (objective sheet, information sheet, student supplements, assignment sheets, and job sheets). The teacher should modify the learning steps as needed to incorporate resources available in the classroom (videotapes, computer software, magazines, etc.) and to address instructional strategies that may be needed to enhance learning for each student. Final copies should be distributed for student use.

  The following icons will be used on the learning activities sheet to denote steps that require additional resources:

  Read a book, magazine, or journal article

  Use a CBT program or other software application

  Access a site on the World Wide Web

  Look at PowerPoint® or other computer presentation

  Watch a videotape

- **Objective Sheet.** This component summarizes each unit for the student and teacher. The objective sheet is based on established performance objectives that state the goals for successful completion of a unit of instruction. Objectives are stated in two forms: unit objectives that state the expected performance of each student after completion of the unit and specific (enabling) objectives that state what the student must be able to do to reach the unit objective.

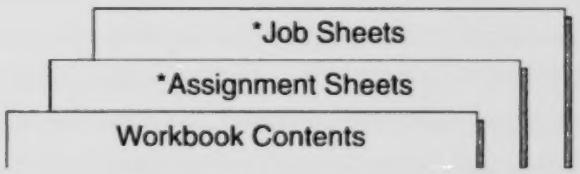
  The objectives should be stressed throughout the teaching/learning process. This will help answer any questions concerning performance requirements for each instructional unit. The objectives can also help determine teaching strategies and instructional methods.

Teachers should modify, delete, or add objectives in order to meet the needs of the students and community. When objectives are added, the teacher should remember to supply the needed information, assignment and/or job sheets, and criterion-referenced test items to cover the new objectives.

- **Information Sheet.** This component provides the student with the essential information for meeting the cognitive objectives in the unit. Teachers will find that the information sheet serves as an excellent guide for presenting background knowledge necessary to develop the skills specified in the unit objective. Students should read the information sheet before the information is discussed in class. Space is provided in the margins for students and teachers to add notes that clarify and/or expand upon the information presented.

- **Student Supplements.** This component is included in a unit of instruction when additional information is needed in order for students to complete one or more of the assignment and/or job sheets. Students are not directly tested over the information presented in a supplement; however, their ability to apply this information may be evaluated in the completion of assignment and/or job sheets.

Student Workbook



*Designates components that may not appear in every unit of instruction

The student workbook is an integral part of the student materials and should be provided to each student. It contains the pen-and-paper exercises and skill tests necessary for student mastery of the course.

- **Assignment Sheets.** The assignment sheets address the learning levels at or above the application level of Bloom's taxonomy. They provide students with an opportunity to use higher-order thinking skills, such as problem solving, synthesizing, analyzing, and evaluating. In addition, they may provide additional opportunities for students to develop their language skills.

  Assignment sheets can be paper-and-pencil activities, as well as those using computer software, videotapes, models, handouts, or other resources as appropriate. Criteria are provided to evaluate student performance objectively.

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- **Job Sheets.** Job sheets are designed as skill tests and give the instructor direction as to the psychomotor skills to be taught, and provide the criteria to evaluate student performance objectively. They also help provide potential employers with a picture of the skills being taught during training and the performances that might be reasonably expected from an individual who has completed the training.

  The teacher should provide students with a copy of each job sheet and/or the procedure's manual and/or job specifications when necessary. The teacher should also discuss the equipment and materials that will be needed for the job and the criteria that will be used to evaluate the student's performance, and demonstrate the procedure prior to having students practice the procedure. Safety should be stressed as part of each demonstration.

  When a student is ready to be evaluated, the teacher should follow the instructions for evaluating student performance which may be found in the suggested activities component of the teacher unit.

- **Glossary.** This optional item is a compilation of the terms and definitions included in each unit of instruction and terms are presented in alphabetical order.

As you use these instructional materials we hope that you will find that they contribute to the quality of your program. If any problems occur or if you have any suggestions for improvement of the materials, please write us at 1500 West Seventh Avenue, Stillwater, OK 74074-4364, or e-mail us at mavcc@mavcc.com.

Training and Competency Profile

Student Information

Program _____ Instructor _____

Name _____ Student ID No. _____

Address _____ Phone _____

Grade _____ School _____

Allergies/Disabilities that might require special accommodation for training (please specify)

_____

In case of emergency, contact _____ Phone _____

Record of Enrollment

Date of Enrollment ____- ____- ____ Total Class Hours_____ Total Hours Absent_____

Date of Withdrawal ____- ____- ____ Total On-the-Job Training Hours_____ Total Hours Tardy_____

Date of Completion ____- ____- ____ Total Lab Hours_____

On-the-Job Training/Work Experience

_____ _____
Place of Employment Address

_____ _____
Supervisor's Name Phone

_____ _____
Duration of Employment Job Title

_____
Job Responsibilities

_____ _____
Place of Employment Address

_____ _____
Supervisor's Name Phone

_____ _____
Duration of Employment Job Title

_____
Job Responsibilities

Training and Competency Profile

Student Evaluation

Directions: Evaluate the student using the rating scale below. Write the appropriate number to indicate the degree of competency achieved. The descriptions associated with each of the numbers focuses on a level of student performance for each of the tasks listed. The written test scoreline is provided for optional teacher use. It may not be applicable in all cases.

Rating Scale: Option A

4 Skilled—Can perform job with no additional training
3 Moderately Skilled—Has performed job during training program; limited additional training may be required.
2 Limited Skill—Has performed job during training program; additional training is required to develop skill.
1 Unskilled—Is familiar with process, but is unable to perform job.
0 No Exposure—No information or practice provided during training program, complete training required.
NA Non-applicable.

Rating Scale: Option B

Yes—Can perform with no additional training
No—Is unable to perform satisfactorily

Unit 1: Oxyacetylene Welding

_____ 1. Light, adjust, and shut down an oxyacetylene welding torch in adherence with safety standards.
_____ 2. Lay beads on flat plate with no filler rod.
_____ 3. Lay beads on flat plate with filler rod.
_____ 4. Weld an outside corner joint in the flat position.
_____ 5. Weld a butt joint in the flat position
_____ 6. Weld a lap joint in the flat position.
_____ 7. Weld a T-joint in the flat position.
_____ 8. Weld an outside corner joint in the horizontal position.
_____ 9. Weld a butt joint in the horizontal position.
_____ 10. Weld a lap joint in the horizontal position.
_____ 11. Weld a T-joint in the horizontal position.
_____ 12. Weld a corner joint in the vertical position.
_____ 13. Weld a butt joint in the vertical position.
_____ 14. Weld a lap joint in the vertical position.
_____ 15. Weld a T-joint in the vertical position.
_____ 16. Weld an edge joint in the overhead position.
_____ 17. Weld a butt joint in the overhead position.
_____ 18. Weld a lapjoint in the overhead position.
_____ 19. Weld a T-joint in the overhead position.
_____ 20. _____
_____ Written Test Score

Unit 2: Oxyfuel Cutting

_____ 1. Set up, adjust cutting flame, and shut down oxyacetylene cutting equipment.
_____ 2. Make 90° cuts and restart a cut on mild steel.
_____ 3. Make a flame beveled cut on mild steel plate.
_____ 4. Cut holes in mild steel.
_____ 5. Layout a pattern on mild steel plate and cut the pattern to specifications.
_____ 6. Cut a pipe bevel by hand.
_____ 7. Set up and cut a 30° bevel with a track-type torch.
_____ 8. _____
_____ Written Test Score

Unit 3: Oxyacetylene Braze Welding and Surfacing

_____ 1. Weld a stringer bead with a bronze rod on steel plate
_____ 2. Braze weld a square groove butt joint in the flat position.
_____ 3. Braze weld a lap joint in the horizontal position.
_____ 4. Repair a worn tool with hardfacing.
_____ 5. _____
_____ Written Test Score

State of Oklahoma Welding Duty/Task Crosswalk

The following state of Oklahoma welding tasks, which are aligned to AWS standards, are covered in this publication. The first column identifies Oklahoma's task by name and number. The second column identifies the exact location by unit number and objective, assignment sheet, or job sheet in this MAVCC publication unless otherwise noted. Oklahoma Welding Tasks present Oxyfuel Cutting as part of the "Combination Welder" occupation. Duty G under this heading prsents Oxyfuel tasks that appears in this MAVCC text.

Occupation: Combination Welder	**MAVCC Tasks**
Duty A: Demonstrate Employability Skills	
A.18 Identify employment opportunities	*Fundamentals of Welding*, Unit 1, Objective 7—Job outlook for welders; Objective 9—Career opportunities for welders; Assignment Sheet 2—Compare employment opportunities in welding
A.19 Identify levels of training recommended for related careers	*Fundamentals of Welding*, Unit 1, Objective 8—What it takes to become a good welder
A.20 Understand salary, wages and benefits packages	*Fundamentals of Welding*, Unit 1, Objective 6—What welders earn
Safety	
A.26 Explain the purpose for safety policies	*Fundamentals of Welding*, Unit 2, Objective 4—Hazard communication; Assignment Sheet 1—Complete the student safety pledge form; Assignment Sheet 5—Identify and correct safety violations
A.27 Discuss the role of OSHA and EPA — Locate information in MSDS	*Fundamentals of Welding*, Unit 2, Objective 6—Purposes of material safety data sheets; Student Supplement 1—Guidelines for interpreting material safety data sheets; Assignment Sheet 2—Interpret a material safety data sheet
A.28 Participate in OSHA training, if possible — Lock Out/Tag Out	*Fundamentals of Welding*, Unit 2, Objective 8—Safety tags and their color coding; Objective 19—Instances when lockout devices should be used
— HAZCOM	*Fundamentals of Welding*, Unit 2, Objective 4—Hazard communication
— MSDS	*Fundamentals of Welding*, Unit 2, Objective 6—Purposes of MSDS; Student Supplement 1—Guidelines for interpreting MSDS; Assignment Sheet 2—Interpret a material safety data sheet

State of Oklahoma Welding Duty/Task Crosswalk

Occupation: Combination Welder	MAVCC Tasks
— Bloodborne Pathogens	*Fundamentals of Welding*, Unit 3, Objective 18—Basic first-aid procedures for various emergency situations
A.29 Explain the proper steps in reporting an accident or emergency	*Fundamentals of Welding*, Unit 3, Objective 16—General steps for handling any emergency situation; Objective 17—General guidelines for first aid emergencies; Assignment Sheet 1—Determine basic first aid measures for given emergency situations
A.30 Explain the hazards associated with specific types of equipment and tools	*Fundamentals of Welding*, Unit 2, Objective 3—General job and shop safety rules; Assignment Sheet 5—Identify and correct safety violations *GMAW/FCAW*, Unit 1, Objective 10—Rules for handling hollow casting or containers; Objective 11—Hazards associated with arc rays
A.31 Perform machine operator safety checks of equipment and accessories, when necessary	*Fundamentals of Welding*, Unit 2, Assignment Sheet 5—Identify and correct safety violations; Unit 4, Objective 21—Basic rules for safe use of power tools and equipment
A.32 Practice tool safety	*Fundamentals of Welding*, Unit 2, Objective 3d—Tool use, maintenance, and storage safety; Unit 3, Objective 9—Rules for handling welding cables and gas and coolant hoses; Unit 4, Objective 20—Rules for hand tool safety; Objective 21—Basic rules for safe use of power tools and equipment; Objective 22—Rules for tool and equipment maintenance
A.33 Describe the types of fire hazards found in the workplace	*Fundamentals of Welding*, Unit 2, Objective 10—Components of fire triangle; Objective 11—Types of fires and classifications; Objective 12—Types of fire extinguishers; Objective 13—Fire extinguisher markings and class of fire they represent; Objective 14—Fire extinguisher operating instructions that follow P-A-S-S; Student Supplement 2—Using Portable Fire Extinguishers; Assignment Sheet 4—Determine correct fire extinguishers to use for various situations; Job Sheet 1—Operate a fire extinguisher

Occupation: Combination Welder	MAVCC Tasks
A.34 Discuss electrical hazards	*Fundamentals of Welding*, Unit 2, Objective 3f—Electrical safety; Unit 3, Objective 19—Treating a victim of electrical shock *GMAW and FCAW*, Unit 1, Objective 7—Electrical safety requirements for GMAW
A.35 Demonstrate safe use of personal protective equipment	*Fundamentals of Welding*, Unit 2, Objective 20—Fall protection systems; Objective 21—Confined space entry; Objective 22—Environmental contaminants that would require you to use a respirator
A.36 Demonstrate safe material handling techniques — Lifting — Transporting — Storing	*Fundamentals of Welding*, Unit 2, Objective 15—Causes of back injuries; Objective 16—Guidelines for lifting and moving items safely; Job Sheet 2—Lift a heavy object properly
A.37 Understand established first aid procedures	*Fundamentals of Welding*, Unit 3, Objective 16—General steps for handling any emergency situation; Objective 17—General guidelines for first aid emergencies; Objective 18—Basic first-aid procedures for various emergency situations; Student Supplement 2—A systematic look at first aid; Assignment Sheet 1—Determine basic first aid measures for given emergency situations
A.38 Practice good housekeeping	Oxyacetylene Welding and Oxyfuel Cutting—All job sheets require students to clean up their work areas and return tools and equipment to proper storage.
A.39 Comply with company safety policies	*Fundamentals of Welding*, Unit 2, Assignment Sheet 1—Complete the student safety pledge form

State of Oklahoma Welding Duty/Task Crosswalk

Occupation: Combination Welder	MAVCC Tasks
Basic Academic Skills	
A.40 Apply mathematical operations involving whole numbers, fractions, decimals, percentages; mathematical word problems, ratios, etc., when necessary — Addition — Subtraction — Multiplication — Division	*Fundamentals of Welding*, Unit 6, Assignment Sheet 1—Add, subtract, multiply, and divide fractions; Assignment Sheet 2—Add, subtract, multiply, and divide decimal equivalents; Assignment Sheet 3—Convert fractions to decimal form, change fractions to a common denominator, and reduce fractions to lowest terms; Assignment Sheet 4—Write fractions as decimals and percents; Assignment Sheet 6—Write decimals as fractions and percents; Assignment Sheet 8—Make conversions with an inches-to-decimal conversation chart.
A.41 Apply advanced mathematical operations, when necessary — Algebra — Geometry — Trigonometry — Calculus — Statistical Methods	*Fundamentals of Welding*, Unit 6, Objective 8—Terms used in geometry; Objective 9—Types of geometric figures; Objective 12—Area of geometric figures; Assignment Sheet 14—Calculate area of geometric figures; Job Sheet 1—Adjust a bevel square to a 45° angle using a framing square, a combination square, and a protractor; Job Sheet 2—Form 90° and 45° angles with a combination square and draw parallel lines on metal stock
A.42 Apply scientific principles, when necessary — Physics — Chemistry	*Fundamentals of Welding*, Unit 5, Objective 4—Metal identification tests; Objective 5—Mechanical properties of metals; Objective 6—Types of mechanical strengths, Objective 7—Physical property of metals; Job Sheet 1—Conduct magnet tests to identify common metals used in welding; Job Sheet 2—Conduct chisel test to identify common metals used for welding; Job Sheet 3—Conduct spark tests to identify common metals used for welding
A.43 Interpret charts, table, and graphs	*Fundamentals of Welding*, Unit 6, Assignment Sheet 7—Make conversions decimals with a decimal equivalent chart; Assignment Sheet 8—Make conversations with an inches-to-decimal conversion chart
A.44 Apply reading and writing skills, when necessary	Most assignment sheets require the student to read and write.

Occupation: Combination Welder	MAVCC Tasks
Blueprint Reading	
A.50 Identify basic elements of blueprints — Terms — Components — Symbols	*Fundamentals of Welding*, Unit 7, "Welding Print Reading" *Fundamentals of Welding*, Unit 7, Objective 1—Terms related to print reading; Objective 2—Basic lines; Objective 13—Symbols
A.51 Discuss different types of drawings	*Fundamentals of Welding*, Unit 7, Objective 4—Isometric and oblique drawings
A.52 Interpret drawings — Bill of Materials — Revisions — Tolerances	*Fundamentals of Welding*, Unit 7, Objective 4—Isometric and oblique drawings; Objective 6—Tolerancing; Objective 15—Requirements for a formal bill of material; Objective 16—Requirements for an informal bill of material; Assignment Sheet 5—Interpret tolerance dimensions in decimals, fractions, and degrees; Unit 8, Assignment Sheet 5—Interpret a welding print and welding procedure specifications
A.53 Interpret symbols	*Fundamentals of Welding*, Unit 7, Objective 13—Symbols
Measurement Tools and Techniques	
A.54 Identify types of measuring instruments	*Fundamentals of Welding*, Unit 6, Objective 6—Types of rules and examples of their graduations
A.55 Use appropriate measurement instrument for a measurement task	*Fundamentals of Welding*, Unit 6, Job Sheet 2—Form 90° and 45° angles with a combination square and draw parallel lines on metal stock
A.56 Read measuring instruments	*Fundamentals of Welding*, Unit 6, Objective 7—Steps in reading a rule; Assignment Sheet 9—Measure distances with 1˝, 1/2˝, and 1/4˝ graduations; Assignment Sheet 10—Measure distances with 1/4˝ and 1/8˝ graduations; Assignment Sheet 12—Measure distances with 1/16˝ graduations; Job Sheet 1—Adjust a bevel square to a 45° angle using a framing square, a combination square, and a protractor; Job Sheet 2—Form 90° and 45° angles with a combination square and draw parallel lines on metal stock

State of Oklahoma Welding Duty/Task Crosswalk

Occupation: Combination Welder	MAVCC Tasks
A.57 Identify the appropriate formula and units for a measurement task	*Fundamentals of Welding*, Unit 6, Objective 11—Squares, rectangles, and triangles and their formulas for calculating their perimeters; Objective 12—Area of geometric figures
A.58 Differentiate between English and Metric measurement systems, when necessary	*Fundamentals of Welding*, Unit 6, Objective 13—English-metric conversion charts and how to use them; Assignment Sheet 13—Make conversations with an English-metric conversion chart
A.59 Communicate measurements using proper symbols or words	*Fundamentals of Welding*, Unit 6, Objective 10—Units of measure and their equivalents
Duty B: Interpret Drawing and Welding Symbols and Written Welding Procedures	
B.01 Interpret basic elements of drawing/sketch	*Fundamentals of Welding*, Unit 7—Welding Print Reading (entire unit)
— Structural members	*Fundamentals of Welding*, Unit 7, Objective 14—Structural shapes
— Sequence of assembly	*Fundamentals of Welding*, Unit 7, Assignment Sheet 8—Construct adjacent parts in an assembly section
— Dimensions of tolerances	*Fundamentals of Welding*, Unit 7, Objective 5—Dimensioning; Objective 7—Methods of dimensioning; Assignment Sheet 5—Interpret tolerance dimensions in decimals, fractions, and degrees
— Scale	*Fundamentals of Welding*, Unit 7, Objective 9—Reduction and enlargement scales
— View interpretation	*Fundamentals of Welding*, Unit 7, Objective 3—Basic views; Objective 12—Types of section views; Student Supplement 2—Orthographic projection; Assignment Sheet 1—Construct a top view; Assignment Sheet 2—Construct a front view; Assignment Sheet 3—Construct a right side view; Assignment Sheet 7—Make a three-view sketch

Occupation: Combination Welder	MAVCC Tasks
— List of materials	*Fundamentals of Welding*, Unit 7, Objective 15—Requirements for a formal bill of materials; Objective 16—Requirements for an informal bill of materials
B.02 Interpret welding symbol information — Type of weld required — Filler metal — Special details — Non-destructive testing requirements	GMAW and FCAW—Unit 2, Job Sheets 5 through 8, 10 through 18, 20 through 24, 27 through 36, 38 through 40, 42 through 44. *Fundamentals of Welding*, Unit 8, Basic Welding Joints and Symbols (entire unit)
Occupation: Combination Welder	**MAVCC Tasks**
Duty G: Perform Manual Oxyfuel (OF) Cutting	
G.01 Perform safety inspections of equipment and accessories — Protective clothing and equipment — Manual OFC equipment and accessories — Oxygen/fuel gas supply systems and accessories — Hand tools — Work area — Communicate hazard warnings	From Oxyacetylene Welding and Oxyfuel Cutting, Unit 2, "Oxyfuel Cutting" — Job Sheets 1, 2, 3, 4, 5, 6, 7, 8, and 9, require student to perform equipment set up to include checking oxygen and fuel cylinders, and connecting regulators. Student must connect hoses, torch body, and tip, and check all connections, including check valves, with leak detector.
G.02 Make minor external repairs to equipment and accessories (preventative maintenance only) — Manufacturer's recommendations — Company repair policy — Equipment troubleshooting *—Regulators*	In all job sheets, Unit 2 "Oxyfuel Cutting," student must set up equipment according to recommendations for both safety and operation.
G.03 Set up maual oxyfuel fas cutting operations on plain carbon steel — Regulator set for appropriate tip/fuel gas — Tip selection (size and type)	In Unit 2, "Oxyfuel Cutting," Job Sheet 3, student must make 90° cuts on plain carbon steel and stop and restart a cut. In Job Sheet 4, student must make a flame-beveled cut on mild steel plate with attention to increased oxygen pressure required for bevel cutting.
G.04 Operate manual oxyfuel cutting equipment — Control gas flow and flame size/tip — Initial lighting procedure — shut down procedures	All activities are covered in all job sheets in Unit 2, "Oxyfuel Cutting."
G.05 Perform straight cutting operations on plain carbon steel plate and pipe	All activities are covered in Job Sheets 1 and 2 in Unit 2, "Oxyfuel Cutting."

G.06 Perform shape cutting operations on carbon steel plate pipe	Unit 2, "Oxyfuel Cutting," Job Sheet 6 requires student to lay out a pattern on mild steel place and make straight and bevel cuts.
G.07 Perform bevel cutting operations on plain carbon steel and pipe	Activity covered in Job Sheet 6 of Unit 2, "Oxyfuel Cutting."
G.08 Remove weld metal from plain carbon steel using weld washing techniques — Tip selection to avoid destruction of metal	Use of scarfing tip to be demonstrated by instructor and used as optional activity by student.
Occupation: Shielded Metal Arc Welder	**MAVCC Tasks**
Duty H: Perform Machine Oxyfuel (OF) Gas Cutting (Track Burner)	
H.01 Perform safety inspections of equipment and accessories — Protective clothing and equipment — Hand tools — Work area — Machine oxyfuel gas cutting (track burner) equipment and accessories) — Oxygen/fuel gas supply systems and accessories — Communicate hazard warning	*Oxyacetylene Welding and Oxyfuel Cutting,* Unit 2, "Oxyacetylene and Oxyfuel Cutting." In Job Sheet 8, "Set Up and Cut a 30° Bevel With a Track-Type Torch," student must wear specified protective equipment including welding googles. Student must inspect area for hazards or unsafe conditions, and use a tip wrench.
H.02 Make minor external repairs to equipment and accessories — Manufacturer's recommendations — Company repair policy — Eqipment troubleshooting *—Regulators*	In Job Sheet 8, Unit 2, "Oxyfuel Cutting," student must follow manufacturer's guidelines for protractor adjustment and tip tightening .
H.03 Set up machine oxyfuel cutting (track burner) operations on plain carbon steel — Regulator set for appropriate tip/fuel gas — Tip selection (size and type) — Alignment of track mechanism	In Job Sheet 8, Unit 2, "Oxyfuel Cutting," student must select a tip according to thickness of metal as selected by instructor and align protractor and torch properly on track.
H.04 Operate machine oxyfuel gas cutting (track burner) equipment — Central gas flow — Initial igniting procedure — Travel speed — Shut down procedures	In Job Sheet 8, Unit 2, "Oxyfuel Cutting," student must light and adjust torch in neutral flame and adjust flame to proper distance off metal. Student must determine travel speed according to tip size and thickness of metal. Student must close oxygen cutting valve, disengage the tractor drive motor, and turn motor off, then turn torch off for safe/proper shut down.
H.05 Perform straight cutting operations on plain carbon steel plate	Job Sheet 6, Unit 2, requires student to lay out a pattern on mild steel plate and cut the pattern to specifications. Pattern requires 6 straight cuts and 1 bevel cut.

Instructional/Task Analysis

Related Information: What the Student Should Know	Application: What the Student Should Be Able to Do

Unit 1: Oxyacetylene Welding

1. Terms and definitions
2. Benefits of learning oxyacetylene welding and cutting
3. Equipment required for oxyacetylene welding
4. Safety rules for oxyacetylene workplace
5. Personal safety requirements
6. Eye protection required for oxyacetylene welding
7. Pressure regulating valves
8. Welding hoses and their characteristics
9. Parts of a welding torch
10. Types of mixers and their purposes
11. Welding tips and their uses
12. Basic safety rules for oxyacetylene cylinders and gases
13. Types of oxyacetylene flames
14. Guidelines for flame adjustment
15. Characteristics and causes of backfire and flashback
16. Welding tip selection
17. Filler rod selection, handling, and safety
18. AWS designations for iron and steel gas welding rods
19. Flux selection, handling, and safety
20. Welding positions
21. Basic types of welds and their AWS symbols
22. Basic welding joints and positions
23. Elements of good fusion welding
24. Rules of thumb for rod and torch angles

Related Information: What the Student Should Know	Application: What the Student Should Be Able to Do
Unit 1: Oxyacetylene Welding (continued)	
25. Guidelines for using the forehand technique in fusion welding	
26. Guidelines for using the backhand technique in fusion welding	
27. Techniques for controlling flame and rod motions	
28. Guidelines for preheating, interpass, and postheating	
29. Procedures for cleanup, inspection, and testing	
30. Steps in setting up cylinders and regulators	
31. Steps in purging oxygen and fuel gas regulators	
32. Final steps in setting up oxyfuel equipment	
	33. Light, adjust, and shut down an oxyacetylene welding torch in compliance with safety standards
	34. Lay beads on flat plate with no filler rod
	35. Lay beads on flat plate with filler rod
	36. Weld an outside corner joint in the flat position
	37. Weld a square-groove butt joint in the flat position
	38. Weld a lap joint in the flat position
	39. Weld a T-joint in the flat position
Unit 2: Oxyfuel Cutting	
1. Match terms related to oxyacetylene and oxyfuel cutting with their definitions.	
2. Complete statements about advantages of oxyacetylene and oxyfuel cutting.	
3. Select true statements about alternate fuels.	
4. Complete statements about alternate fuel gas data.	

Related Information: What the Student Should Know	Application: What the Student Should Be Able to Do
Unit 2: Oxyfuel Cutting (continued)	
5. Select true statements about equipment requirements for alternate fuels.	
6. Solve problems about liquid oxygen applications and safety.	
7. Identify parts of an equal-pressure cutting torch.	
8. Identify parts of an injector cutting torch.	
9. Select true statements about cutting tip design.	
10. Complete statements about high-volume heating tip design.	
11. Select guidelines for acetylene cutting tip selection.	
12. Select true statements about guidelines for cleaning acetylene cutting tips.	
13. Match acetylene tip cleaning tools with their uses.	
14. Select true statements about rules for tip use.	
15. Select true statements about metal preparation for oxyfuel cutting.	
16. Arrange in order the steps in properly starting a cut.	
17. Complete statements about techniques for restarting a cut.	
18. Select true statements about techniques for cutting straight lines.	
19. Select techniques for controlling kerf and drag.	
20. Complete statements about elements of a good cut.	
21. Select causes for characteristics of poor cuts.	
22. Complete statements about safety requirements for oxyacetylene and oxyfuel cutting.	

Related Information: What the Student Should Know	Application: What the Student Should Be Able to Do
Unit 2: Oxyfuel Cutting (continued)	
23. Select true statements about characteristics of manifold systems.	
24. Select true statements about characteristics of track-type cutting machines.	
25. Select true statements about characteristics of shape cutting machines.	
26. Select true statements about characteristics of automated cutting machines.	
27. Select true statements about characteristics of pipe beveling machines.	
28. Complete statements about eye protection required for oxyacetylene and oxyfuel cutting.	
	29. Set up, adjust cutting flame, and shut down oxyacetylene cutting equipment.
	30. Set up, adjust cutting flame for star pattern, and shut down oxyfuel cutting equipment.
	31. Make 90° cuts and restart a cut on mild steel
	32. Make a flame-beveled cut on mild steel plate.
	33. Cut holes in mild steel.
	34. Lay out a pattern on mild steel plate and cut the pattern to specifications.
	35. Set up and cut a 30° bevel on a track-type torch.
	36. Cut a pipe bevel by hand.
	37. Set up and bevel a pipe with a pipe beveling machine.

Related Information: What the Student Should Know	Application: What the Student Should Be Able to Do

Unit 3: Oxyacetylene Braze Welding and Surfacing

1. Match terms related to oxyacetylene braze welding and surfacing with their definitions.
2. Differentiate between the definitions of fusion welding and braze welding.
3. Differentiate between the definitions of brazing and braze welding.
4. Select true statements about the advantages of braze welding.
5. Select true statements about the limitations of braze welding.
6. Complete statements about precoating in braze welding.
7. Select true statements about the purposes of flux.
8. Complete statements about the characteristics of filler rods for braze welding.
9. Complete statements about important factors in successful braze welding.
10. Select true statements about techniques used in preparing joints for braze welding.
11. Complete statements about techniques used to remove oxides in preparing joints for braze welding.
12. Complete statements about techniques used for braze welding steel and cast iron.
13. Match braze welding problems with their causes.
14. Differentiate between the definitions suffacing and hardfacing.
15. Select true statements about the advantages of bronze surfacing.
16. Complete statements about limitations of bronze surfacing.
17. Differentiate between methods of preparing new and cast iron surfaces for bronze surfacing.

Related Information: What the Student Should Know	Application: What the Student Should Be Able to Do
Unit 3: Oxyacetylene Braze Welding and Surfacing (continued)	
18. Select true statements about guidelines for bronze surfacing.	
19. Select true statements about guidelines for hardfacing applications.	
20. Match types of hardfacing alloys with their definitions.	
21. Complete statements about hardfacing powders.	
22. Complete statements about the advantages of hardfacing with an oxyacetylene torch.	
23. Complete statements about guidelines for preparing surfaces for hardfacing.	
24. Identify requirements for machining surfaces to be hardfaced.	
25. Select true statements about preheating and cooling requirements for hardfacing.	
26. Complete statements about techniques used for oxyacetylene hardfacing.	
27. Select true statements about techniques for making a second pass when oxyacetylene hardfacing.	
28. Complete statements about safety precautions used for hardfacing.	
	29. Weld a stringer bead with a bronze rod on steel plate.
	30. Braze weld a square groove butt joint in the flat position.
	31. Braze weld a lap joint in the horizontal position.
	32. Repair a worn tool with hardfacing.

Basic Skills Icons and Classifications

To assist teachers and students in identifying and documenting where academic and workplace skills are being taught, MAVCC has adopted a system that uses icons and a list of specific tasks to identify the skill or skills that are used in each focus assignment, assignment sheet, and job sheet.

A matrix for each of the ten broad skill areas has been included in this edition and reflects key elements from *What Work Requires of Schools: A SCANS Report for America 2000,* a 1991 study by the U.S. Department of Labor; *Workplace Basics: The Skills Employers Want,* a three-year study conducted jointly by the American Society for Training and Development (ASTD) and the United States Department of Labor (DOL); and other national and state sources.

Each of the ten broad skill areas—reading, writing, mathematics, science, oral communication, interpersonal or relating, critical thinking, employability, social studies, and technology—is represented by the icon presented below.

Reading Skills

- Reading Comprehension
- Research/Reference
- Functional Reading

Writing Skills

- Language
- Composition
- Research
- Functional Writing

Math Skills

- Operation and Calculation
- Math Application
- Data Analysis and Display
- Functional Math

Basic Skills Icons and Classifications

Science Skills

- General Science
- Life Science
- Physical Science
- Earth Science

Oral Communication Skills

- Oral Presentation
- Listening
- Interactive Communication

Interpersonal or Relating Skills

- General Relating
- Teamwork/Cooperation
- Leadership/Influence

Critical Thinking Skills

- Cognitive Activities

Employability Skills

- Job Search/Selections
- Job Acquisition/Development
- Resource Management
- Job Safety

Social Studies Skills

- Information Analysis
- Social Studies Application
- Functional Social Studies

Technology Skills

- Selection
- Application
- Maintenance/Troubleshooting

Reading Skills

Reading Comprehension	• Gain factual information • Distinguish fact, opinion, and inference • Recognize stereotyping and bias • Recognize propaganda • Analyze cause and effect • Draw conclusions • Make generalizations • React to written material • Apply word analysis techniques • Analyze and apply what has been read to specific task • Comprehend written information for main ideas • Determine what information is needed
Research/ Reference	• Select useful resources • Locate resources • Find materials in library • Use standard references • Use in-book reference tools • Use audiovisual media • Use computer database • Use magazines and newspapers
Functional Reading	• Interpret forms and records • Follow written instructions • Interpret graphics and symbols • Interpret abbreviations/acronyms • Read aloud • Apply/understand technical words that pertain to subject

Basic Skills Icons and Classifications

Writing Skills

Language

- Use standard grammar, spelling, and capitalization
- State ideas clearly

Composition

- Use complete sentences
- Develop preliminary outline
- Use topic sentences
- Use introductory/closing paragraphs
- Compose reports
- Compose essays
- Proofread and edit
- Construct graphics and symbols

Research

- Take notes
- Use note cards
- Create bibliography
- Use footnotes
- Outline material

Functional Writing

- Complete forms and records
- Write instructions
- Write letters
- Write job applications
- Write resumes
- Use word processing
- Use computer graphics
- Use content area vocabulary

Math Skills

Operation and Calculation	• Round off numbers • Estimate answers • Use scientific notations • Use exponential notations • Calculate with whole numbers • Calculate with fractions • Calculate with decimals • Convert whole numbers to fractions • Convert whole numbers to decimals • Solve numerical expressions • Solve formulae and equations • Obtain squares and square roots • Convert units of measure • Perform metric calculations
Math Application	• Solve word problems • Select/apply mathematical formula • Select/apply mathematical procedure • Use English and metric measures • Solve time/rate/distance problems • Solve ratio/proportion problems • Solve percent problems • Apply techniques of scaling • Apply algebra principles • Apply geometry principles • Apply trigonometry principles
Data Analysis and Display	• Interpret charts and tables • Interpret graphs • Collect/record data • Apply sampling techniques • Apply principles of probability • Construct charts and tables • Construct graphs • Calculate statistics • Interpret statistics • Interpret plans/blueprints • Draw facility to scale

Math Skills (Continued)

Functional Math

- Make measurements
- Perform banking transactions
- Make change
- Solve practical problems
- Calculate gross earnings
- Solve income/expense problems
- Prepare a budget
- Calculate interest
- Solve interest problems
- Calculate sales tax
- Determine income tax
- Use calculator for computation
- Use computer for computation
- Use computer spreadsheets
- Apply computation skills as they are actually used on the job
- Calculate measurements taken from measuring devices
- Perform/prepare an inventory
- Calculate and compare shipping costs
- Prepare financial report

Science Skills

General Science

- Apply computing skills
- Apply scientific method of inquiry
- Conduct experiments
- Investigate science ethics
- Investigate science history
- Investigate/apply economics in technology
- Use scientific instruments
- Investigate/apply technology
- Collect specimens
- Construct model to depict basic concept of ----

Life Science

- Identify/classify living organisms
- Investigate biological history of the earth
- Investigate food chains, webs, pyramids
- Investigate/apply principles of human development
- Investigate/apply principles of genetics/heredity
- Investigate/apply principles of anatomy/physiology
- Investigate health issues
- Observe health code/sanitation requirements

Physical Science

- Analyze/classify matter
- Investigate forms/changes of matter
- Investigate forms/changes of energy
- Investigate/apply chemical properties
- Investigate/apply physical laws

Earth Science

- Investigate physical characteristics of the earth
- Investigate geological history of the earth
- Investigate physical forces acting on the earth
- Solve problems of longitude, latitude, and time zones
- Investigate conservation of physical resources
- Investigate conservation of living resources
- Investigate issues of environmental impact
- Apply science principles to environmental issues

Basic Skills Icons and Classifications

Oral Communication Skills

Oral Presentation

- Make informative presentations
- Make persuasive presentations
- Present personal opinion/viewpoint
- Use good speaking techniques
- Select/use words effectively
- Use effective body language
- Present appropriate appearance
- Integrate audio and/or visual materials into oral presentations
- Adapt presentation to specific audience

Listening

- Apply active listening skills
- Distinguish fact, opinion, and inference
- Draw conclusions/make generalizations
- Analyze/identify point of view

Interactive Communication

- Give/follow oral directions
- Apply questioning techniques
- Conduct/receive interviews
- Analyze/apply nonverbal communication
- Work effectively in a group
- Communicate with clients/customers/patients
- Communicate with coworkers
- Communicate with supervisors
- Communicate with professional colleagues/associates
- Apply telephone etiquette

Interpersonal or Relating Skills

General Relating

- Investigate/apply communication process models
- Analyze/apply nonverbal communication
- Investigate/apply cross-cultural communication
- Interact with coworkers
- Interact with supervisors
- Interact with clients/customers/patients
- Interact with professional colleagues/associates
- Interact with family/friends
- Participate in group activities
- Participate in industrial relations/functions
- Identify personal values/attitudes
- Apply information to life experiences

Teamwork/ Cooperation

- Identify values/attitudes
- Identify needs/drives
- Select/apply appropriate behavior
- Investigate/identify personal styles
- Investigate/identify group/corporate climate
- Give/receive feedback
- Identify hidden purposes
- Investigate/apply group dynamics
- Control undesirable/inappropriate behavior
- Resolve conflicts
- Clarify goals/objectives
- Devise "win/win" situations
- Build consensus
- Generate ideas
- Present point of view

Leadership/ Influence

- Analyze/apply leadership styles
- Analyze/apply management styles
- Obtain confidence of others
- Develop esteem in self/others
- Persuade others
- Analyze/apply motivation techniques
- Provide positive coaching

Basic Skills Icons and Classifications

Critical Thinking Skills

Cognitive Activities

- Collect/record information
- Identify critical elements/issues
- Define a problem
- Identify underlying causes
- Apply a problem-solving model
- Analyze/synthesize information
- Identify/analyze underlying assumptions
- Draw conclusions
- Predict results/outcomes
- Identify/evaluate consequences
- Identify/develop alternatives
- Evaluate alternatives
- Select an alternative
- Devise a solution
- Create a finished product
- Apply intuitive thinking techniques
- Transfer knowledge/training to new situations
- Apply new technology
- Develop an action plan
- Evaluate results/outcomes
- See relationship between two or more ideas, objects, or situations

Employability Skills

Job Search/ Selections

- Analyze personal occupational aptitudes/preferences
- Investigate employment prospects of a career field/occupation
- Investigate training requirements for a career field/occupation
- Investigate benefits of a career field/occupation
- Compare/evaluate career options
- Analyze impact of work on individual and family life

Job Acquisition/ Development

- Develop personal career path
- Locate appropriate jobs
- Analyze duties/requirements/benefits of specific job
- Master specific job task/procedure
- Complete job-related applications
- Write a letter of application
- Write personal resume
- Interview for a job
- Apply business etiquette
- Practice good work habits/attitudes
- Practice good personal presentation
- Develop self confidence/esteem
- Develop effective leadership
- Deal effectively with supervisors
- Deal effectively with coworkers
- Deal effectively with professional colleagues/associates
- Deal effectively with customers/clients/patients
- Follow established rules, regulations, and policies
- Promote the goals and values of the organization
- Exert a high level of effort and perseverance towards goal attainment
- Set high standards for self in completion of a task

Resource Management

- Complete task in timely manner
- Determine cost, time, and resources to complete a task
- Perform routine tasks related to equipment operation and/or maintenance

Job Safety

- Demonstrate safe use of tools, equipment, and supplies
- Observe safety rules
- Wear safety equipment
- Follow safety procedures
- Demonstrate proper use of safety device

Social Studies Skills

Information Analysis

- Collect/record data
- Interpret graphical information
- Construct graphical information
- Interpret maps/globes
- Interpret statistical information
- Analyze/interpret demographic information
- Distinguish trends and predicts impact of actions on systems operations

Social Studies Application

- Investigate/apply U.S. history
- Investigate/apply world history
- Investigate/apply U.S. geography
- Investigate/apply world geography
- Investigate/apply principles of government/politics
- Investigate/apply principles of economics
- Investigate/apply principles of ethics
- Investigate/apply principles of sociology
- Investigate/apply cross-cultural studies

Functional Social Studies

- Practice responsible personal economics
- Prepare a personal budget
- Use credit responsibly
- Practice good work ethics
- Participate in industrial relations
- Interact with people of different races/cultures
- Investigate/participate in government
- Investigate/apply American legal practices
- Select/use sources of information on current events
- Analyze current events
- Analyze consumer issues
- Analyze social issues
- Analyze conservation/ecology issues
- Analyze social impact of science/technology
- Analyze economic impact of science/technology
- Understand how social, organizational, and technological systems work and operate effectively

Technology Skills

Selection	• Choose procedures, tools, or equipment including computers and related technologies that will produce the desired results
Application	• Demonstrate the proper procedures for setting up and operating equipment, including computers and their programming systems
Maintenance/ Troubleshooting	• Perform maintenance on equipment, including computers and other technologies • Identify and correct problems with equipment • Report damaged or broken equipment to appropriate individual

BASIC SKILLS MATRIX

	Reading	Writing	Mathematics	Science	Oral Communication	Interpersonal	Critical Thinking	Employability	Social Studies	Technology
Unit 1 Oxyacetylene Welding	X						X	X		X
Unit 2 Oxyfuel Cutting	X		X				X	X		X
Unit 3 Oxyacetylene Braze Welding and Surfacing	X						X	X		X

BEST COPY AVAILABLE

Tools, Equipment, and Materials List

Acetylene cylinders
Ball peen hammer
Center punch
Chains or cylinder supports
Chipping hammer
Cutting table with grated surface and slag box
Cutting torch body
Cylinder wrench
Face shield
Filler rods for braze welding
Filler rods for hardfacing
Fire-brick work table
Flux
Fuel gas cylinders
Gas welding rods
Hand-guided, tractor-type, or shape-cutting machines
Hard surfacing powders (optional)
Leak detector
Liquid oxygen cylinders
Mild steel pate, cast iron, and pipe as specified
Oxygen cylinders
Pipe beveling machine
Pliers
Portable grinder/sander
Pressure regulators for oxygen, acetylene, and fuel gas
Protective clothing as specified
Safety glasses
Selected brazing tips
Selected cutting torch tips
Selected welding torch tips
Soapstone
Sparklighter
Temperature-indicating crayons or pellets
Tip cleaner
Tip drill
Tip nip
Torch wrench
Vise
Welding and cutting goggles
Welding hoses with reverse-flow check valves
Welding torch body
Wire brush

Unit Contents

Teacher Components

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1—Oxyacetylene Cylinder and Torch Assembly 1–29
2—Oxyacetylene Fusion Welding Flames 1–31

Student Components

Student Page

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Objective Sheet 1–5

Information Sheet 1–7

* Job Sheets

1—Light, Adjust, and Shut Down an Oxyacetylene Welding Torch in Compliance with Safety Standards 1
2—Lay Beads on Flat Plate with No Filler Rod 7
3—Lay Beads on Flat Plate with Filler Rod 11
4—Weld an Outside Corner Joint in the Flat Position 15
5—Weld a Square-Groove Butt Joint in the Flat Position 19
6—Weld a Lap Joint in the Flat Position 23
7—Weld a T-Joint in the Flat Position 27

* The Job Sheets are located in the Student Workbook

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.

Suggested Activities

- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- When demonstrating the job sheets, impress upon students the need to do things in order: properly and safely setting up equipment, properly preparing joints, working with a neutral flame, and using tack welds.

- Use the job sheets to promote the concept of "dexterity" and good eye-hand coordination required for manipulation of the torch, the welding rod, and the weld puddle. Alert students to the value of eye-hand coordination in other arc welding processes such as GTAW and GMAW.

- Emphasize the importance of visually inspecting welds, and impress students that major parts of welding include preparation of the joint before the weld starting and inspection of the weld after welding has ended.

- Demonstrate the shutdown procedure used in the event of backfire or flashback. Different manufacturers may recommend shutting off either the fuel or oxygen first in the event of flashback, but abide by the guideline from the American Welding Society: the most important concern is to get both valves closed quickly.

- Stress safety at all time and demand that students wear safety glasses in the welding facility.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.

- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.

- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

Sample A

4—**Skilled**—Can perform job with no additional training.
3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
1—**Unskilled**—Is familiar with process, but is unable to perform job.
0—**No exposure**—No information or practice provided during training program.

Sample B

Yes—Can perform job with no additional training.
No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- *Basic Oxyacetylene Welding, Cutting, and Heating Practices*. New York: Union Carbide Corporation, 1989.
- Connor, Leonard P., ed. *Welding Handbook*, Eighth Edition, Vol. 1, Welding Technology. Miami, FL: American Welding Society, 1987.
- *Harris High Performance Gas Apparatus and Equipment*. Gainsville, GA: Harris Calorific, Inc., The Lincoln Electric Company, 2000.
- O'Brien, R.L., ed. *Welding Processes, Welding Handbook*, 8th ed., Vol. 2. Miami, FL: American Welding Society, 1991.
- *Safety Meeting* (a brochure to promote safe handling of oxy-fuel gas equipment). Watertown, SD: Smith Equipment Division, Tescom Corporation.

- *Victor Apparatus and Equipment Master Catalog.* Denton, TX: Victor Equipment Company.

Electronic Media

- HOB-30 "Oxyacetylene Welding, Cutting, and Brazing." Covers safety, basics, and many applications, complete with instructor's guide. 16mm film and 1/2" videotape. Available from:

  Hobart School of Welding Technology
  Trade Square East
  Troy, OH 45373
  513-332-5217

- KEN-2 "Gas Welding and Cutting Training Program." Covers safety, basics, and applications of welding and cutting, complete with welding and cutting kit and other materials. 16mm film available in both English and Spanish. Available from:

  Ken Cook Education Systems
  12856 West Silver Spring Drive
  P.O. Box 207
  Butler, WI 53007
  (800) 362-2665

Written Test

Name _____

Date _____ Score_____

Objective 1

Match the terms with their definitions.

1. Preheating
2. Tack weld
3. Base metal
4. Welding positions
5. Fusion welding
6. Stress relief
7. Gap wire
8. Penetration
9. Interpass heating
10. Postheating

_____ a. Metal to be welded, brazed, or cut

_____ b. A welding process that joins metals by heating them to a melting point and allowing them to fuse or flow together

_____ c. A wire used for correct spacing of butt joints

_____ d. Application of heat to a base metal during a welding process

_____ e. Distance from the original surface of the base metal to that depth at which fusion stops

_____ f. Heating after a welding operation to provide uniform cooling and stress relief

_____ g. Heating prior to a welding or cutting operation

_____ h. A process whereby base metals are heated to even temperature below the critical range, held at that temperature for a given time, and uniformly cooled to avoid distortion, cracking, or other stress-related problems

_____ i. A short weld used to temporarily hold workpieces in place

_____ j. A numbered reference to the physical positioning of a workpiece with 1 as flat, 2 as horizontal, 3 as vertical, and 4 as overhead

Written Test

Objective 2

Select true statements about benefits of learning oxyacetylene welding and cutting by placing an "X" in the blanks next to the true statements.

_____ a. Teaches methods used in forming, recognizing, and controlling a weld puddle

_____ b. Teaches methods of properly holding and manipulating welding equipment and develops techniques that are useful in other welding processes

_____ c. Provides practice leading to good eye-hand coordination required in the welding trade

_____ d. Teaches the basics of metallurgy and the characteristics of metals being welded or cut

_____ e. Provides a familiarity with the welding workplace and its activities

_____ f. Teaches a welding skill that will increase employability when facing job demands that require both arc and oxyacetylene skills

Objective 3

Complete a list of equipment required for oxyacetylene welding. Circle the information that best completes individual items.

a. Oxygen cylinder

b. Acetylene cylinder

c. Pressure (**valve, regulator**) for oxygen

d. Pressure (**valve, regulator**) for acetylene

e. Two hoses (**encased together, separated for easy identification**)

f. Welding torch with (**assorted tips, basic welding elbow**)

g. Welding goggles and (**safety glasses, face shield**)

h. Sparklighter

i. (**Pressure, Check**) valves to prevent flashback

j. Cylinder wrench

k. Chipping hammer and (**grinder, wire brush**)

Objective 4

Complete statements about safety rules for the oxyacetylene workplace by circling the correct answers.

a. Keep work area free of grease, oil, and flammable materials because flying sparks can (**fly for several feet, explode**) and cause a fire.

b. Cool or quench hot metal and extinguish all sparks before leaving the work area, (**and always, but do not**) quench during a welding process.

c. Do not leave torches, tips, or (**hot metal, hoses**) where they can be accidentally touched by a co-worker or visitor.

d. Never carry matches or lighters filled with butane or propane into any work area where any kind of (**welding, welding or cutting**) is taking place.

e. Do not withdraw too much volume at one time from an (**oxygen, acetylene**) tank because a high demand of (**oxygen, acetylene**) could withdraw acetone from the cylinder and create a hazardous condition.

Objective 5

Select solutions for personal safety requirements. Circle the number of the item that provides the best solution to each of the following.

a. A co-worker is working in a shirt that has pockets that do not have pocket flaps. The problem can quickly be solved by:

(1) Stopping and changing shirts
(2) Taping the pocket openings shut
(3) Putting the job off until later

b. A lady welder is working while wearing a plastic cap. The problem can be solved by:

(1) Using a welding helmet
(2) Wrapping a damp towel around her hair
(3) Putting on a proper welding cap

c. A co-worker is wearing a pair of low-cut sneakers while welding. The problem can be solved by:

(1) Changing to a pair of shoes with high tops
(2) Changing positions so the feet will be clear of the welding area
(3) There is no problem because he is welding, not cutting

d. A co-worker says that wearing safety glasses under goggles is not really needed. The co-worker is:

(1) Probably right
(2) Probably wrong
(3) Absolutely wrong

Written Test

Objective 6

Complete statements concerning eye protection required for oxyacetylene welding by circling the correct answers.

a. Wear (**safety glasses, a face shield**) when cleaning or chipping base metals.

b. Wear (**safety glasses, welding goggles**) and a face shield when grinding joints or bevels.

c. Wear welding goggles to protect eyes from spatter, and choose goggles with a lens shade dark enough to protect eyes from (**radiation burns, sparks**).

d. Play it safe and start with a lens shade too dark to see the work zone, then work down to a lighter shade that affords (**a good view of the work zone, protection**) without straining your eyes.

Objective 7

Select problems about pressure regulating valves. Circle the best solution to each of the following

a. A co-worker needs to know where to find the oxygen cylinder pressure. You should advise the co-worker to:

   (1) check the regulator gauges because one shows working pressure for the torch and the other shows cylinder.
   (2) Turn the adjusting screw until the working pressure begins to register.
   (3) Look at the working pressure gauge because it should be the same as the cylinder pressure.

b. You notice that a co-worker is using an acetylene pressure that is too high. You should advise the co-worker to:

   (1) Adjust the acetylene on the porch needle valve.
   (2) Turn the acetylene adjusting screw counterclockwise to decrease pressure.
   (3) Quit welding until the pressure automatically adjusts itself.

Objective 8

Differentiate between welding hoses and their characteristics. Circle the appropriate answers to each of the following.

a. Acetylene hoses are always (**red, black, green**).

b. Oxygen hoses are usually (**green, red**) but sometimes (**black, yellow**).

c. Acetylene connectors have (**a V-groove and left-handed threads, a plain surface and right-handed threads**).

d. Oxygen connectors have (**a V-groove and left-handed threads, a plain surface and right-handed threads**).

Objective 9

Complete statements about parts of a welding torch by circling the correct answers.

a. The torch body is that part of a torch designed to be (**held, adjusted**); it contains two (**control, needle**) valves to control the flow of acetylene and oxygen.

b. The welding head is the torch component that contains a mixer or injector, the mixing (**throat, chamber**), and the welding tip to control the flame.

Objective 10

Solve problems about types of mixers and their purposes. Circle the number of the best solution to each of the following situations.

a. The planning for a welding project calls for the most efficient use of oxygen and fuel gases for oxyacetylene welding applications. This means the project requires:

(1) A good injector type mixer
(2) An equal-pressure type mixer

b. A project that requires oxygen be supplied at high pressure requires:

(1) A good injector type mixer
(2) An equal-pressure type mixer

Objective 11

Select true statements about welding tips and their uses by placing an "X" in the blanks next to the true statements.

_____ a. Welding tips should be selected according to the thickness of the filler rod.

_____ b. Tip sizes vary from 000 for use on 1/32" metal, up to a number 12, which can be used on medal from 3" to 4".

_____ c. Replaceable elbow tips are one-piece tips that fit onto the torch body and provide long cone flame characteristics for general purpose welding and brazing.

_____ d. Other welding tips use replaceable welding tip ends that can be easily switched for working with oxy-propane or oxy-natural gas applications.

Objective 12

Solve problems about basic safety rules for oxyacetylene cylinders and gases. Circle the number of the best solution to each of the following.

a. You are getting ready to attach a regulator to an oxygen cylinder, but first you need to:

(1) Put the regulator on the acetylene cylinder.
(2) Blow out the oxygen cylinder valve.

b. You have placed the regulator gauges on the cylinders and are getting ready to open the cylinder valves, but first you need to:

(1) Release the adjusting screw on the regulators.
(2) Stand to one side.

c. You have installed the regulatory properly and now want to open the cylinder valve, but first you should:

(1) Stand on the same side of the regulator.
(2) Stand on the side opposite the regulator.

d. You have done everything to set up the regulator properly, so now you can open the cylinder valve, but be sure to:

(1) Open the valve slowly.
(2) Open the valve all the way as quickly as you can.

e. You are adjusting acetylene pressure and you know you must always keep one rule in mind about acetylene pressure, and that rule is:

(1) Do not compress acetylene at pressures higher than 15 psi.
(2) Do not compress acetylene at pressures higher than 7 psi.

Objective 13

Complete a chart of oxyacetylene flame characteristics and uses. Place the number of the use in the appropriate blank on the chart

Name	Characteristics	Uses
Oxidizing	Excess oxygen to acetylene burning ration with no acetylene feather, and makes a harsh, hissing sound	a. _____
Neutral X	Burns equal amounts of oxygen and acetylene, and has a clear, clean-edged inner cone	b. _____
Reducing X to 2X (Lightly carburizing)	Burns slightly more acetylene than oxygen, acetylene feather appears just beyond the point of the neutral flame, and is also a carburizing flame	c. _____
Carburizing 2X to 3X	Excess acetylene to oxygen burning ration with an acetylene feather two to three times the length of the inner cone	d. _____

a. Used for backhand welding and for welding mild steel with low-alloy rods

2. The most used flame for oxyacetylene applications.

3. Used for some hardfacing, but must be used selectively because it adds carbon to base metals.

4. Least used because it oxidizes metal, but is used for braze welding with a bronze rod.

Objective 14

Select true statements about guidelines for flame adjustment by placing an "X" in the blanks next to the true statements.

_____ a. To secure a neutral flame, always start with an excess of acetylene, then increase the flow of oxygen or decrease the flow of acetylene until the acetylene feature disappears from the center cone.

_____ b. An excess of oxygen is easy to spot, but an excess of acetylene is difficult to spot except that it will cause molten metal to spark excessively.

_____ c. Make sure regulator working pressures are those recommended for the tip size you are using.

_____ d. Beginning welders should use the harshest flame the welding torch can produce.

_____ e. Cut back flame length slightly when a flame is too harsh.

Objective 15

Complete statements about causes of backfire and flashback. Circle the information that best completes each of the following statement.

a. Backfire is a momentary backing of the flame into the welding tip; it is usually accompanied by a loud (**hiss, pop**).

b. Overheating a tip, using a tip (**too close to, too far away from**) the work, or touching a tip to the work can all cause backfire and flashback.

c. An insufficient volume of oxygen or acetylene or (**extra low, incorrect**) gas pressures can also cause backfire and flashback.

d. (**Dirty, Worn**) seating surfaces, leaks from loose tips, and failure to purge the equipment can also cause backfire and flashback.

e. Flashback is a continued burning back of the flame into the tip, mixer, or torch body and is accompanied by a loud HISS or (**BANG, SQUEAL**).

f. Operator, equipment, and even the workplace can be in danger with both backfire and flashback; remember the auditory alert sounds for both, a loud (**hiss, pop**) for backfire and a lous HISS (**BANG, SQUEAL**) for flashback — the sounds indicate immediate danger and the need for immediate shut down.

Objective 16

Complete statements about the ways to control backfire and flashback. Circle the information that best completes each of the following statements.

a. Backfire is a momentary backing of flame into a welding tip and is controlled with (**flashback, arresters, reverse flow check valves**) on both the oxygen and fuel gas intakes to the torch.

b. Flashback is a condition where a flame not only goes into the torch tip, but continues burning through the tip and torch body so that it endangers both hoses and the (**regulators, entire system**).

c. It is a common arrangement to have reverse flow check valves at the entry points to the (**torch, regulators**) while flashback arresters are installed at the oxygen and fuel gas regulator on cylinders or at the regulators on manifold systems.

d. Both reverse flow check valves and flashback arresters should be inspected at (**weekly intervals, regular intervals**) and replaced if there are evident signs of wear.

Objective 17

Complete statements about welding tip selection by circling the correct answers.

a. Welding tip sizes should be selected according to the thickness of the (**metal to be welded, rod size**) and type of fuel gas to be used.

b. Drill size listed with a tip indicates the size of the orifice when new so the correct size tip cleaner can be selected and the orifice can be properly checked for (**wear, performance**).

c. Tip manufacturer's recommended regulator pressures for fuel gases should not exceed the minimum or maximum recommended for a specific (**size tip, fuel gas**).

d. Tip size and regulator pressures recommended by the manufacturer should be (**used on thicker metals, carefully followed**).

e. Gas consumption data on tip selection charts are for estimating purposes, and the actual consumption will vary with the material being welded and (**tip size, operator's skill**).

f. Gas pressure recommendations on tip data charts are usually based on a hose length of (**25, 10**) feet, and longer lengths of hose should have about 3 psi added per each additional (**25, 10**) feet.

Objective 18

Complete statements about filler rod selection, handling, and safety by circling the correct answers.

a. Select a rod that has the (**same, same or similar**) properties of the metal base.

b. Select a rod that is the correct size (**for the thickness of the metal being welded, for the welding tip**).

c. Keep rods (**covered, properly labeled**) and store in a clean, dry place.

d. Keep hot filler rods away from (**combustible, electrical**) materials.

e. (**Bend, Shorten**) the end of the filler rod to prevent eye injuries.

Objective 19

Select true statements about AWS designations for iron and steel gas welding rods by placing an "X" in the blanks next to the true statements.

_____ a. Rods are identified with a two-letter, two-digit designation such as RG65

_____ b. The "R" indicates a rod, the "G" indicates the rod is to be used with gas welding, and the "65" indicates manufacturer's identification number.

Written Test

Objective 20

Select true statements about flux selection, handling, and safety by placing an "X" in the blanks next to the true statements.

_____ a. Flux selection will always depend on the type of metal being welded, weld design, and specifications.

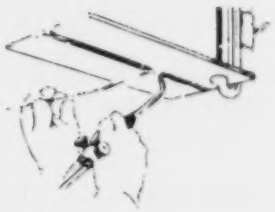
_____ b. Flux should normally be used for welding mild steel.

_____ c. After use, the lid on a tin of flux should be securely resealed before storing.

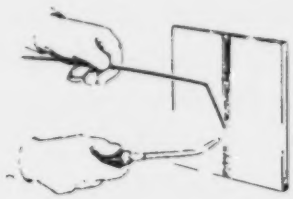
Objective 21

Identify welding positions. Write your answers in the blanks provided.

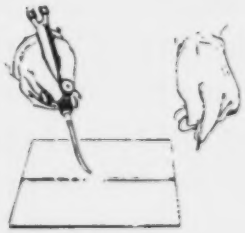
1. Position 2 or horizontal
2. Position 4 or overhead
3. Position 1 or flat
4. Position 3 or vertical



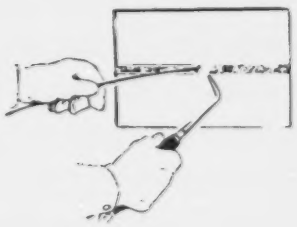
a. _____



b. _____



c. _____



d. _____

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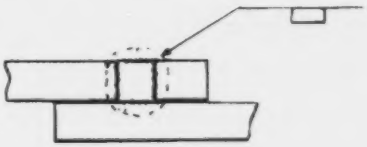
Objective 22

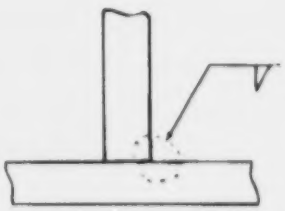
Identify basic types of welds and their AWS symbols. Write your answers in the blanks provided.

1. Plug or slot weld
2. Fillet weld
3. Beads
4. Groove weld

a. _____



b. _____

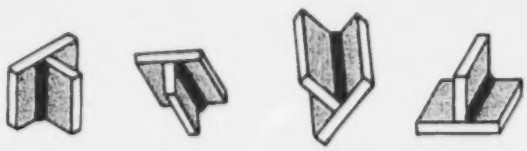


c. _____

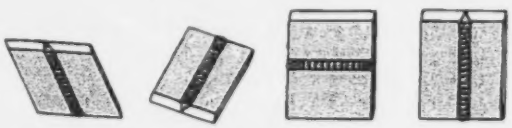
d. _____

Objective 23

Identify basic welding joints and positions. Place the joint name below the appropriate illustration and list the positions in order, noting whether the welds are G or F. Write your answers in the blanks provided.



a. Joint name: _____ Positions left to right _____



b. Joint name: _____ Positions left to right _____

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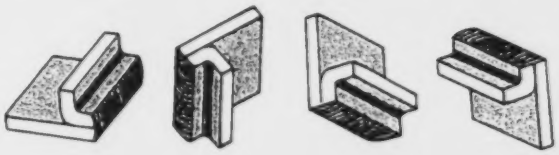
c. Joint name: _____ Positions left to right _____



d. Joint name: _____ Positions left to right _____

e. Joint name: _____ Positions left to right _____

Objective 24

Solve problems about elements of good fusion welding. Circle the number of the best solution to each of the following problems.

a. A fellow student complains about poor weld quality and slow speed with a project being worked on. The problem could probably be correctly by:

(1) Paying more attention to the workpiece
(2) Paying more attention to flame and rod angles
(3) Paying more attention to rod selection

b. Another student is working on a welding project, and obviously has a flame-to-work distance of almost 1/2". This can be corrected by:

(1) Using a reducing flames
(2) Adjusting flame-to-work distance to 1/4".
(3) Adjusting flame-to-work distance to 1/8".

c. On a welding project, your rod keeps sticking to the weld and is difficult to pull loose. You can correct this problem by:

(1) Melting the rod loose with the flame
(2) Selecting a different size tip
(3) Selecting a different welding rod

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d. A fellow student is working with a long welding rod in a very clumsy fashion. The problem can be corrected by:

(1) Using a shorter rod
(2) Bending the rod about 8″ from the end to give a better view of the weld area
(3) Changing torch and flame angles slightly

Objective 25

Select true statements about rules of thumb for rod and torch angles by placing an "X" in the blanks next to the true statements.

_____ a. The best practice for beginners is to hold both the rod and the torch at 45° angles from the surface of the workpiece to create a 90° angle between the two.

_____ b. When the torch is held at a 45° angles, it not only reduces heat input directly under the tip, but spreads heat ahead of the weld for better control.

_____ c. The flame should always be pointed or angled off to one side.

_____ d. The more vertical the angle of the torch flame, the more heat input under the torch tip.

_____ e. With experience, more vertical torch angles are helpful in certain situations, but used improperly, a more vertical torch angle usually results in burning a hole through the base metal.

Objective 26

Select true statements about guidelines for using the forehand technique in fusion welding by placing an "X" in the blanks next to the true statements.

_____ a. For a right-handed operator, welding proceeds from right to left, but welding proceeds from left to right for a left-handed operator.

_____ b. The torch flame is pointed toward the unfinished end of the weld, and the filler rod is pointed toward the finished end of the weld.

Objective 27

Select true statements about guidelines for using the backhand technique in fusion welding by placing an "X" in the blanks next to the true statements.

_____ a. For a right-handed operator, welding proceeds from left to right, but welding proceeds from right to left for a left-handed operator.

_____ b. The torch flame is pointed toward the finished end of the weld, and the filler rod is pointed toward the unfinished end of the weld.

_____ c. The backhand technique is good, and beginners should use it from the start.

Written Test

Objective 28

Complete statements about techniques for controlling flame and rod motion by circling the correct answers.

a. Keep both the flame and the filler rod in almost constant motion with the flame moving slowly forward across the line of the weld in a (**side to side, back and forth**) motion as the rod moves in and out of the leading edge of the puddle.

b. Keep the motion of the rod (**the same as, opposite**) the motion of the flame so that the inner cone of the flame is pointed directly at the rod for only a part of each back and forth cycle.

c. When the end of the rod is drawn away from the puddle, don't draw it away very far, but keep it in the (**outer, inner**) cone of the flame.

d. Remember that puddle control can also come from the heat of the flame and rod motion because the flame (**adds, takes away**) head while the rod (**adds, takes away**) heat, so control can be a product of these elements too.

Objective 29

Select true statements about guidelines for preheating, interpass, and postheating by placing an "X" in the blanks next to the true statements.

_____ a. With the exception of cast iron, preheating, interpass, and postheating in oxyacetylene welding are usually accomplished in the welding process.

_____ b. Additional preheating and postheating are usually required with aluminum.

_____ c. An oxyacetylene flame is also used for preheating, interpass, and postheating in other welding processes.

Objective 30

Select correct procedures for cleanup, inspection, and testing. Circle the number of the statement that provides the best answer to each of the following.

a. What should happen with all welds from first to last?

(1) They should be chipped free of slag.
(2) They should be allowed to cool.
(3) They should be cleaned with a wire brush until the entire weld is completely visible.

b. Inspection should take place after every weld because with a visual inspection you can visually tell the quality of the weld, and you can also identify:

(1) The need for cleaning the weld better.
(2) The need for testing.
(3) The need for a different weld sequence.

c. A good example of nondestructive testing is:

(1) A guided bend test.
(2) Ultrasonic testing.
(3) Nick-break test.

Objective 31

Arrange in order the steps for setting up cylinders and regulators by placing the correct sequence numbers (1-7) in the appropriate blanks.

_____ a. Release pressure on both regulators by turning each regulator adjusting screw counterclockwise until tension is completely released on the adjusting screw.

_____ b. Stand to one side of the oxygen cylinder valve, open it momentarily and then close it quickly to purge the valve, then repeat the process for the fuel gas cylinder.

_____ c. Remove cylinder valve caps.

_____ d. Attach oxygen regulator to oxygen cylinder valve and tighten only with a cylinder wrench.

_____ e. Attach fuel gas regulator to fuel gas cylinder valve and tighten only with a cylinder wrench

_____ f. Secure cylinders with a chain to a cylinder cart or wall support.

_____ g. Examine cylinder valve threads for damage and wipe clean any dust, oil, or grease with a clean, dry cloth.

Objective 32

Select true statements about steps in purging oxygen and fuel regulators by placing an "X" in the blanks next to the true statements.

_____ a. Stand to one side and open oxygen cylinder valve SLOWLY until inlet pressure gauge needle moves slowly to maximum reading, then open cylinder valve fully.

_____ b. Purge oxygen regulator by turning the adjusting screw counterclockwise momentarily, then clockwise to release pressure.

_____ c. Stand to one side and open fuel gas cylinder valve, and if it is an acetylene cylinder, open only one-half to three-quarters of a turn.

_____ d. Purge fuel gas regulator by turning the adjusting screw counterclockwise to open it momentarily, then turn adjusting screw clockwise to release pressure.

Objective 33

Select procedures for final steps in setting up oxy-fuel equipment. Circle the number beside the best answer for each of the following situations.

a. When hoses are attached to regulators and to a torch base, you should use:

(1) A cylinder wrench
(2) An open end wrench
(3) An adjustable wrench

a. When you're purging hoses, you need to turn each regulator adjusting screw clockwise for 3 to 5 seconds, and then you need to:

(1) Open the need valves on the torch
(2) Start welding
(3) Turn the adjusting screws counterclockwise to release pressure

a. All threaded connections should be checked for leaks with:

(1) A leak test solution
(2) Soapy water
(3) Any kind of liquid detergent

*Permission to duplicate this test is granted.

Answers to Written Test

Objective 1

a.	3	f.	10
b.	5	g.	1
c.	7	h.	6
d.	9	i.	2
e.	8	j.	4

Objective 2

a, b, c, d, e, f

Objective 3

c. Regulator
d. Regulator
e. Encased together
f. Assorted tips
g. Safety glasses
i. Check
k. Wire brush

Objective 4

a. Fly for several feet
b. But do not
c. Hot metal
d. Welding or cutting
e. Acetylene, acetylene

Objective 5

a. Taping the pocket openings shut
b. Putting on a proper welding cap
c. Changing to a pair of shoes with high tops
d. Absolutely wrong

Objective 6

a. Safety glasses
b. Safety glasses
c. Radiation burns
d. A good view of the work zone

Objective 7

a. 1
b. 2

Objective 8

a. Red
b. Green, black
c. A V-groove and left-handed threads
d. A plain surface and right-handed threads

Objective 9

a. Held; needle
b. Throat

Objective 10

a. 2
b. 1

Answers to Written Test

Objective 11	b, c, d
Objective 12	a. 2 b. 1 c. 2 d. 1 e. 1
Objective 13	a. 4 b. 2 c. 1 d. 3
Objective 14	a, c, e
Objective 15	a. pop b. too close to c. incorrect d. Dirty e. SQUEAL F. pop, SQUEAL
Objective 16	a. reverse flow check valves b. entire system c. torch d. regular intervals
Objective 17	a. Metal to be welded b. Wear c. Size tip d. Carefully followed e. Operator's skill f. 25, 25
Objective 18	a. Same or similar b. For the thickness of the metal being welded c. Properly labeled d. Combustible e. Bend
Objective 19	a
Objective 20	a, c
Objective 21	a. 2 b. 4 c. 3 d. 1

Objective 22	a. 3 b. 1 c. 2 d. 4
Objective 23	a. T-joint, 3F, 4F, 1F, 2F b. Butt joint, 4G, 1G, 2G, 3G c. Lap joint, 1F, 2F, 3F, 4F d. Edge joint, 2G, 3G, 4G, 1G e. Corner joint, 3F, 4F, 1F, 2F
Objective 24	a. 2 b. 3 c. 1 d. 2
Objective 25	a, b, d, e
Objective 26	a, b
Objective 27	a, b
Objective 28	a. Back and forth b. Opposite c. Outer d. Adds, takes away
Objective 29	a, c
Objective 30	a. 3 b. 2 c. 2
Objective 31	a. 7 b. 4 c. 2 d. 5 e. 6 f. 1 g. 3
Objective 32	a, c
Objective 33	a. 2 b. 3 c. 1

Teacher Supplement 1—History of Oxyacetylene Welding and Cutting

Early History

An Englishman named Edmund Davey discovered acetylene in 1836. Eventually, acetylene was produced from calcium carbide, and this resulted in the development of acetylene as a light source. Street lights were among the earliest applications of acetylene, and by 1895, the gas was being piped and used for residential lighting in England.

Industrial Applications of Acetylene

In 1895, a French chemist discovered that acetylene and oxygen together produced a hotter flame than any other gas or combination of gases. This knowledge spawned experimentation with acetylene and oxygen in combination for welding metals together and for cutting metals. In fact, another Frenchman developed an injector-type acetylene torch in 1900. After success in Europe, the injector-type torch was introduced in America in 1906.

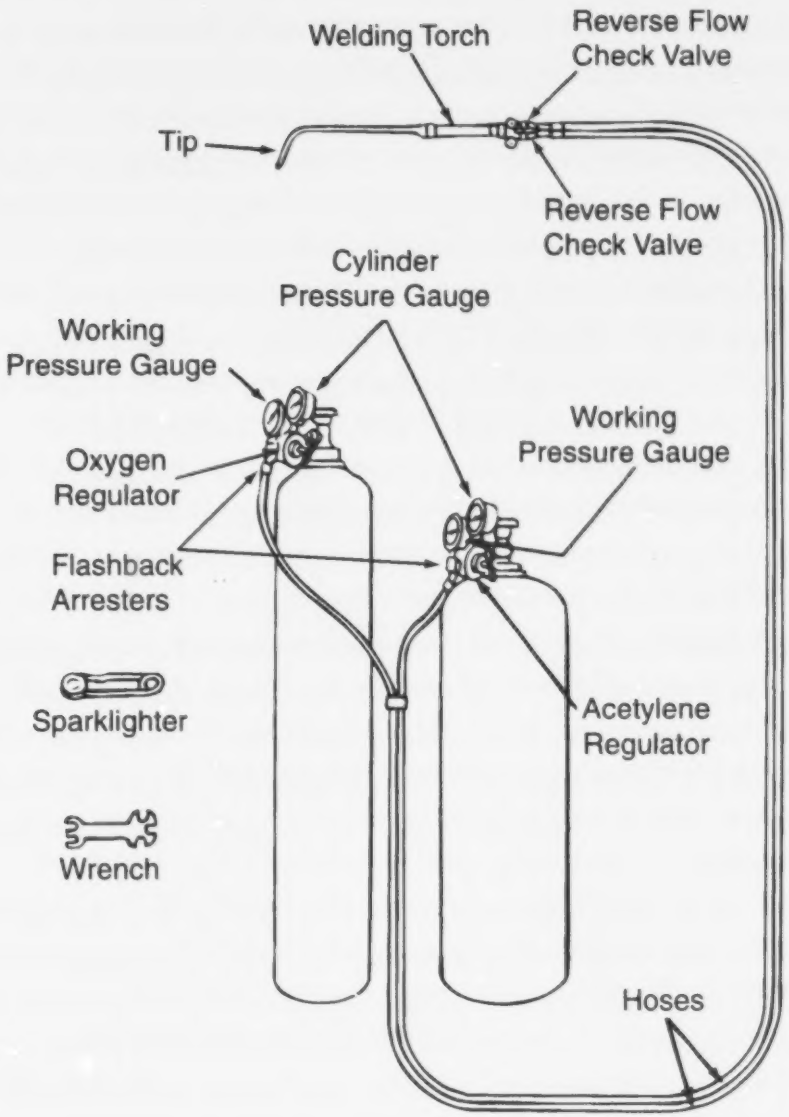
Later History of Oxyacetylene Welding and Cutting

With ongoing improvements in torch design and delivery systems for gases, oxyacetylene became the major welding process in the America of the early 1900s. The process was not only popular in industry, it spread to applications in construction, maintenance, and repair work. The popularity of oxyacetylene stemmed from the fact that the process was highly portable and could be used on almost all types of metals.

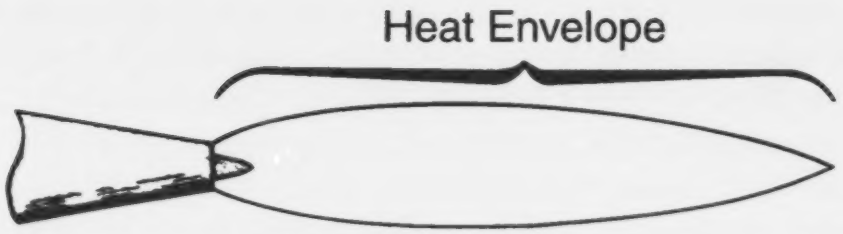
The Present and Future of Oxyacetylene Welding and Cutting

The discovery of faster arc welding processes such as GMAW (gas metal arc welding) and GTAW (gas tungsten arc welding) replaced oxyacetylene welding in many industrial applications. But the portability of oxyacetylene rigs still gives oxyacetylene and oxy-fuel systems the edge for certain applications. The systems are popular for farm equipment repair, and oxyacetylene cutting is still one of the handiest cutting processes in industry and a favorite with maintenance personnel. Total systems are relatively inexpensive, the systems are portable, and because one system can be used for both cutting and welding, the future of oxyacetylene welding and cutting is very secure.

Oxyacetylene Cylinder and Torch Assembly

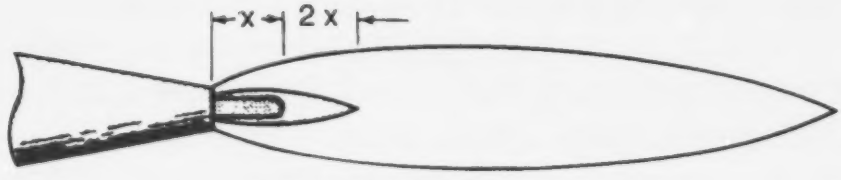


Oxyacetylene Fusion Welding Flames

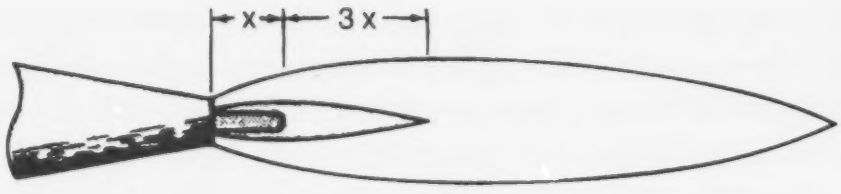


Oxidizing Flame

Neutral Flame



Reducing Flame



Carburizing Flame

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* Job Sheets are located in the Student Workbook

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.

Suggested Activities

- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Prepare a demonstration of alternate fuels as presented in Objectives 3 and 4. If you do not have alternate fuels in your school, plan a trip to a facility so students can see alternate fuels in use for cutting or for heating.

- Stress the economy of liquid oxygen when students study Objective 6 and if you do not have liquid oxygen available for demonstration, plan a trip that will permit students to see liquid oxygen in use, places like a scrap steel cutting yard or a pattern cutting facility.

- Prepare a Demonstration for Objectives 7 and 8. If you do not have an injector torch in your shop, arrange for a supplier to bring one to the school and demonstrate its use. Compare the injector torch with an equal-pressure or positive pressure torch and point out the advantages and applications of both types of torches.

- Because track-type cutting devices and shape-cutting devices vary from manufacturer to manufacturer, have manufacturers' brochures or other literature available to reinforce Objectives 24, 25, and 26. Also be sure to read Job Sheet 7 carefully and make adjustments as required to facilitate track-type equipment in your own school or shop.

- Always talk safety, especially when it concerns eye safety around oxyacetylene and oxyfuel cutting where flying sparks always pose a danger. Use Objective 28 to stress once again the importance of safety in the classroom, the shop and everyplace in the welding industry.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.

- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.

- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

Sample A

4—**Skilled**—Can perform job with no additional training.
3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
1—**Unskilled**—Is familiar with process, but is unable to perform job.
0—**No exposure**—No information or practice provided during training program.

Sample B

Yes—Can perform job with no additional training.
No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- Connor, Leonard P., ed. *Welding Handbook, Eighth Ed., Vol. 1, Welding Technology.* Miami, FL: American Welding Society, 1989.
- Oates, William R., ed. *Welding Handbook, Eighth Ed., Vol. 3, Welding Technology.* Miami, FL: American Welding Society, 1996.
- *Harris High Performance Gas Apparatus Equipment.* Gainesville, GA: Harris Calorific, Inc.
- *Harris Alternate Fuel Equipment.* Gainesville, GA: Harris Calorific, Inc.

Suggested Activities

Suggested Supplemental Resources

Print Media

- *Oxyfuel Gas Cutting Operator's Manual, C4.2-90.* Miami, FL: American Welding Society, 1990.
- *Operator's Manual for Oxyfuel Gas Heating Torch Operations, C4,3-2-90.* Miami, FL: American Welding Society, 1983.

  Order from AWS at 1-800-334-9353 or on the web at http://www.aws.org

Electronic Media

- *Brazing Techniques*, NIM 55-273-V92. Video shows types of fuel gases, rods, and torch adjustments use to braze. Calhoun, KY: Nimco.

  Order from Nimco at 1-800-962-6662 or on the web at http://www.nimco.com

Written Test

Name _____

Date _____ Score_____

Objective 1

Match the terms with their definitions.

1. Slag
2. Wraparound
3. Drag line
4. Kerf
5. Soapstone

_____ a. A condition where the most distant portion of the cutting stream lags behind the stream nearest the cuKing tip

_____ b. The width of the cut produced during a cutting process

_____ c. A nonmetallic residue left after oxyacetylene cutting

_____ d. A talc-based marking pencil that has a soapy feel and is used for marking lines on workpieces

_____ e. A pliable strip of durable gasket material with edges that are perfectly straight and parallel so that it provides a guide for marking a straight line around the circumference of a pipe

Objective 2

Complete statements concerning about the advantages of oxyacetylene and oxyfuel cutting by circling the information that best completes each statement.

a. Both oxyacetylene and oxyfuel cutting are not dependent on electrical power and are readily (**portable, obtainable**).

b. Both oxyacetylene and oxyfuel cutting equipment are (**equal in cost, relatively inexpensive**) when compared to other cutting procedures like plasma arc cutting.

c. When properly executed, oxyacetylene cutting can deliver a high-quality cut on low carbon steel plate up to (**3/16˝, 1˝**) thick, but cuts on thicker plate may require an alternate fuel application.

d. Oxyacetylene cutting is (**seldom, usually**) done manually, but is readily adaptable to automatic processes.

Written Test

Objective 3

Select true statements about alternate fuels by placing an "X" in the blanks next to the true statements.

Note: For a statement to be true, all parts of the statement must be true.

_____ a. Alternate fuels for oxyfuel applications include Mapp®, Propylene, Propane, and Natural Gas and others.

_____ b. Alternate fuels are popular because of their:

- Economy
- Convenience
- Performance
- Attractive cylinders

_____ c. Alternate fuels are economical because they offer more BTUs per dollar, less cylinder handling cost, less cylinder rental, and equipment lasts longer.

_____ d. Alternate fuels are convenient because they offer more product per cylinder, less weight per cylinder, and less maintenance per cylinder.

_____ e. Alternate fuels perform better on many applications because of more BTUs per cubic foot, less chipping and grinding, less top edge rollover, less hardening of face cut, and broad preheat adjustment range.

_____ f. Alternate fuels are safer because they resist flashback and backfire, they can be used at higher pressures, less UV protection is required, and they do produce more soot.

Objective 4

Complete statements about alternate fuel gas data by filling in the blanks with the correct answers.

a. As a rule of thumb, and with the proper gas apparatus, one large cylinder of alternate fuel will do the same amount of work as approximately five large cylinders of _____.

b. Acetylene continues to be the preferred gas for cutting thin plate of 3/16″ or less, for piercing, for beveling, for flame hardening, and for gas _____.

c. Alternate slower-burning fuel gases are often selected for cutting heavy plate of 1" or more, for a broad range of heating applications, for plate clean-up, and for precise preheat _____ control.

Objective 5

Select true statements about equipment requirements for alternate fuels by placing an "X" in the blanks next to the true statements.

Note: For a statement to be true, all parts of the statement must be true.

_____ a. Using an alternate fuel with equipment designed for acetylene will provide the same benefits an alternate fuel can offer.

_____ b. Merely changing from an acetylene to an alternate fuel tip does not offer all the benefits of an alternate gas; the alternate fuel gas will perform better with an equipment conversion to an equal pressure mixer.

_____ c. Injector mixers designed for alternate fuels mix the oxygen and fuel gas thoroughly for increased BTU output and maximum flame temperature.

_____ d. Injector mixers, as opposed to equal pressure mixers, provide exceptional flame stability and a minor fluctuation in gas pressure does not adversely affect flame stability and torch performance.

_____ e. Injector mixers are easy to adjust and operate, and adjusting the oxygen valve provides more or less preheat because the injector automatically maintains the optimum oxy/fuel ratio.

_____ f. If necessary, injector mixers can operate efficiently on fuel gas pressures less than 1 PSIG.

Objective 6

Solve problems about liquid oxygen applications and safety. Circle the number beside the information that best solves each of the following problems.

a. A facility that uses 7 or 8 tanks of pressurized oxygen every day is losing production time changing out oxygen cylinders throughout the day. Is there a problem and if so, how would you solve it?

1. No problem. Switch to larger sized compressed oxygen tanks.

2. Yes. Switch to liquid oxygen tanks.

b. You see a co-worker start to roll a liquid oxygen tank across the floor to a new job location. Is there a problem and if so, how would you solve it.

1. Yes, there's a problem. It is dangerous to roll a liquid oxygen cylinder on the floor. Advise the co-worker to use a cylinder cart to transport the cylinder upright.

2. There is no problem. Just tell the co-worker to clear a pathway so the cylinder can be rolled without hitting something or somebody.

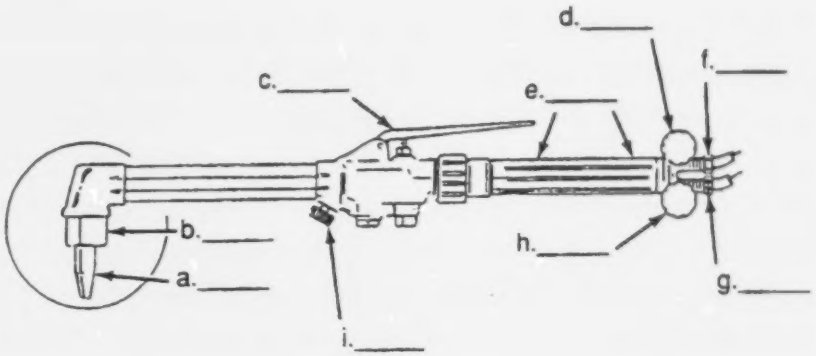
c. The boss at a facility that is considering changing from pressurized oxygen cylinders to liquid oxygen cylinders says the volume difference is not that great and it's not worth changing. Is there a problem and if so, how would you solve it?

1. There is no problem. The important factor is simply getting a dealer that will give the facility the best price on pressurized oxygen.

2. Yes, there's a big-time problem. It would take almost 18 standard cylinders of oxygen to equal one cylinder of liquid oxygen. The switch would definitely be a major improvement in operations.

Objective 7

Identify parts of an oxyacetylene cutting torch. Place the number of the part in the appropriate blank.



1. Oxygen fitting
2. Acetylene fitting
3. Oxygen torch needle valve
4. Acetylene torch needle valve
5. Torch body
6. Oxygen cutting lever
7. Oxygen preheat needle valve
8. Tip nut
9. Slip-in tip

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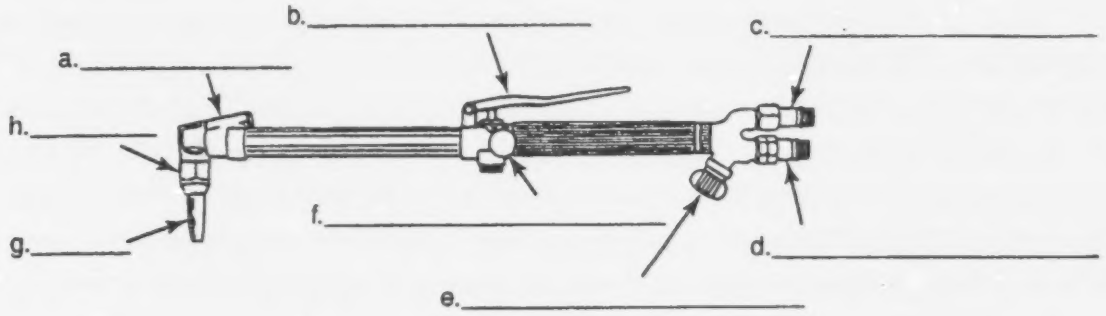
Objective 8

Identify parts of an injector cutting torch. Write your answers in the blanks provided.



1. Injector mixer
2. Cutting oxygen valve
3. Oxygen reverse flow check valve
4. Fuel gas reverse flow check valve
5. Fuel gas needle valve
6. Preheat oxygen valve
7. Tip
8. Tip nut

Objective 9

Select true statements about cutting tip design by placing an "X" in the blanks next to the true statements.

_____ a. Although it is time consuming to change a cutting tip, the tips can be adapted to different thicknesses of metal.

_____ b. Cutting tips are designed with only one preheat orifice and only one oxygen orifice.

_____ c. Preheat orifices provide a mixture of oxygen and acetylene for preheating a base metal.

_____ d. The single oxygen orifice directs a pressurized stream of pure oxygen onto the heated metal to accelerate the oxidation process that blows the metal away and completes the cut.

_____ e. Oxyacetylene cutting tips have to be tightened with a wrench.

Objective 10

Complete statements about high-volume heating tip designs by circling the correct answers.

a. Tips designed to direct high volume gas flow for heating a confined area are classified as heavy duty heating tips or nozzles and are often referred to as (**"rosebuds", "daisies"**).

b. Since these heavy-duty, high-volume tips are designed strictly for heating, they do not have a (**center, circular**) orifice like cutting tips do.

c. Rosebuds for high-volume acetylene heating have no center orifice and the heating orifices are (**oval, round**) and in a ring.

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d. Acetylene rosebuds are frequently used with (**larger tips, extension tubes**) to obtain better heat concentration.

e. Rosebuds for high-volume fuel gas heating have no center orifice and the heating orifices are (**round, slotted**) and in rings.

f. Another readily observable feature of a fuel-gas rosebud is the (**raised, depressed**) ring around the tip face, this design permits the rosebud to cradle the flame and concentrate the heat, another economy factor of fuel gases.

Objective 11

Select guidelines for acetylene cutting tip selection. Circle the number of the best answer to teach of the following situations.

a. A co-worker is just beginning a job. When selecting the cutting tip, the worker should consider:

1. Using as new a tip as possible.
2. How fast the job done must be finished.
3. Picking a tip recommended for the thickness of the material to be cut.

b. If a co-worker complains about slow cutting speed, the problem could easily be:

1. Fuel pressures are set too high
2. A different size tip is required because the cutting tip definitely affects cutting speed.
3. He or she is holding the torch too far away from the workpiece.

Objective 12

Select true statements about guidelines for cleaning cutting tips by placing an "X" in the blanks next to the true statements.

_____ a. Because cutting tips inevitably pick up carbon and/or slag, clean cutting tips monthly.

_____ b. Always select a cieaning probe smaller than the orifice to be cleaned; never force too large a cleaning prove into an orifice.

_____ c. Take special care not to break the cleaning probe off inside an orifice.

_____ d. Be careful with the seating edges of cutting tips because some of them can be easily damaged.

Objective 13

Match tip cleaning tools with their uses. Put your answer in the appropriate blank.

1. Tip cleaner
2. Tip nip
3. Tip drill

_____ a. A miniature drill; used for cleaning and reconditioning orifices

_____ b. A device with a series of small file-like probes that are gauged to match specific orifice openings; used to remove carbon buildup inside the tip

_____ c. A circular-shaped device with small steel cutting blades inset so it can be placed over the entire end of the tip; used to both clean and restore the face of the tip

Objective 14

Select true statements about rules for tip use by placing an "X" in the blanks next to the true statements.

_____ a. Use a tip as a hammer to chip slag off a cut only when you really have to.

_____ b. Never try to clean a tip by rubbing it on fire brick or against anything not designed for tip cleaning.

_____ c. Never use an oily or greasy wrench to tighten a cutting tip, and never use an oily rag to clean dirt from a tip.

Objective 15

Select true statements about metal preparation for oxyfuel cutting by placing an "X" in the blanks next to the true statements.

_____ a. For all critical cutting that requires following layout lines, burn metal free of oil and grease.

_____ b. Remove scale and rust with a grinder.

Objective 16

Arrange in order the steps for properly starting a cut by placing the correct sequence numbers (1-4) in the appropriate blanks.

_____ a. Place the cutting tip so that the preheat flame is half on the metal and half off the edge of the metal, and the tip is perpendicular to the metal surface.

_____ b. When cutting starts, tilt the cutting tip slightly in the direction of the cut and move the tip at a constant speed along the cut line.

_____ c. Place the tips of the preheat inner cones as close as possible to the metal without touching it.

_____ d. Preheat the starting point until the metal is cherry red, then depress the oxygen cutting lever.

Written Test

Objective 17

Complete statements about techniques for restarting a cut by circling the correct answers.

a. Anytime cutting stops, release the oxygen cutting lever (**slowly, immediately**), preheat the restarting point at the edge only, and start again as if beginning a cut.

b. (**Blowholes are, Slag is**) the biggest problem with restarting a cut, and (**blowholes, slag**) can be avoided by if you:

   1. Stop torch travel (**after, before**) reieasing the oxygen cutting lever.

   2. Move the torch into the scrap area beyond the cutting line to form a corner or a curl about 1/4″ long so the cut can be restarted in the scrap area and moved cleanly back to (**the original cutting line, a new cutting line**).

c. Avoid cutting across slag when restarting because the slag will (**fly in all directions, explode**) and create a hazard.

Objective 18

Select true statements about techniques for cutting straight lines by placing an "X" in the blanks next to the true statements.

_____ a. Hold the torch in your right hand with your thumb on the cutting lever and the torch centered in front of your body.

_____ b. Support the torch in your left hand with a firm grip that will not allow the torch to drift.

_____ c. As you move the torch along the cutting line, roll your left hand slightly to the left from time to time to make the adjustment required to keep the cutting flame straight along the line.

Objective 19

Select techniques for controlling kerf and drag. Circle the number of the statement that provides the best answer to each of the following situations.

a. Good oxyacetylene cutting requires proper tip selection and proper travel speed, but another important element is:

   1. Metal thickness
   2. Proper fuel gas pressures.
   3. Proper layout.

b. The thickness of the metal being cut determines tip selection and fuel gas pressures, but another important element is:

   1. Length of fuel gas hoses.
   2. Workplace environment.
   3. Torch angle.

c. As a general rule, torch angle should vary with:

1. The thickness of the metal being cut.
2. The type of tip selected.
3. Settings of fuel gas pressures.

Objective 20

Complete statements about elements of a good cut by circling the information that best completes each statement.

a. The edge is (**square, sharp**).

b. Drag lines are (**vertical and clean, straight and deep**).

c. There is no adhering slag at the (**bottom, top**) edge of the cut.

Objective 21

Select causes for characteristics of poor cuts. Circle the number of the information that best identifies the cuases for hte following characteristics of poor cuts.

a. Bad gouging at the bottom of a cut indicates that:

1. The preheat flame was not hot enough.
2. The preheat flame was too hot.

b. A melted top surface and excessive adhering slag indicates:

1. The preheat flame was too hot.
2. The preheat flame was not hot enough.

c. Several things can cause a cut to get completely out of control, but more than likely it is that:

1. Acetylene pressure is too low.
2. Oxygen pressure is too high and the tip size too small.

d. When irregularities are prominent in the drag line, it usually means that:

1. Cutting speed was too slow.
2. Cutting speed was too fast.

e. A pronounced break in the drag line and an irregular cut edge usually indicates that:

1. Cutting speed was too slow.
2. Cutting speed was too fast.

Objective 22

Complete statements concerning safety requirements for oxyacetylene and oxyfuel cutting by circling the correct answers.

a. When oxyacetylene cutting, follow (**all the, setup**) rules that apply to safe oxyacetylene welding.

b. Because higher oxygen pressures create showering sparks, use (**shielding screens, lower pressures**) to protect nearby areas.

c. Perform cutting on a proper cutting table that provides a work area with a grated surface that permits slag to drop through into a (**slag, scrap**) box.

d. Do not cut or weld on a masonry floor because moisture trapped in the masonry can heat rapidly and cause the floor to (**explode, crack**).

e. Because cutting sparks (**are dangerous, can fly long distances**), move flammable materials a safe distance from the cutting area.

f. Do not set oxygen pressure too high; too high a setting causes sparks to blow and (**consumes, wastes**) oxygen too.

g. Do not cut into (**a barrel, any container**) because it may still contain the residue of highly explosive materials.

h. Keep cutting as far away from (**gas cylinders, other work areas**) as hose length will permit.

Objective 23

Select true statements about characteristics of manifold systems by placing an "X" in the blanks next to the true statements.

_____ a. Manifoids are systems that pipe oxygen and acetylene from two or more oxygen or acetylene tanks to provide a continuous gas supply when only one cylinder would be inadequate.

_____ b. A manifold system should be large enough to supply volume for the smallest size tip used.

_____ c. A manifold should be equipped with a water seal flash arrester on the oxygen side.

_____ d. Manifold systems save space when a number of work stations are required.

_____ e. Manifold systems permit a school or shop to buy gases in quantity, reduce costs, and save money.

_____ f. Fuel gases and liquid oxygen are not used in manifold systems.

Objective 24

Select true statements about characteristics of track-type cutting machines by placing an "X" in the blanks next to the true statements.

_____ a. Track-type cutting machines require setup, alignment, and adjustment by an operator.

_____ b. Track-type machines operate on tracks mostly designed for horizontal cutting, and none can cut in the overhead position.

_____ c. The carriage is motor-driven and speed is controlled by a governor.

_____ d. Some track-type machines have provisions for mounting two or more torches.

_____ e. Track-type machines are use mostly for making square or beveled cuts, and cannot be modified to cut circles.

Objective 25

Select true statements about characteristics of shape cutting machines by placing an "X" in the blanks next to the true statements.

_____ a. Machines vary in design from a single wheel to three wheels with attachments for cutting straight lines, bevels, circles, and irregular shapes.

_____ b. Machines are adjustable to many steel forms including rod and pipe, and can be used to cut horizontally or vertically.

_____ c. Machines are controlled by operators who control the speed and direction of a cutting torch that is centered in front of or beside a drive mechanism.

Objective 26

Select true statements about characteristics of automated cutting machines by placing an "X" in the blanks next to the true statements.

_____ a. Automated cutting machines are usually designed for a specific job where the cutting of multiple identical shapes contributes to high productivity.

_____ b. Automated machines function as tracing devices that use a photocell or an electric eye to trace a pattern, or use magnetic devices to trace a metal template.

_____ c. These machines usually require manual torch movement to give an operator precise control over gas torch operations.

_____ d. These machines are sometimes programmed numerically with punched tape fed into a master control unit, but they are sometimes controlled with solid state digital devices such as a computer or a programmable logic controller.

Written Test

Objective 27

Complete statements about characteristics of pipe beveling machines by circling the correct answers.

a. Pipe beveling machines are designed specifically for cutting beveled angles, T's and Y's, and other connecting shapes for (**pipe, pipe and plate**).

b. Beveling machines may be (**manually operated or motorized, manually operated only**).

c. The basic machine design is a split horseshoe that fits the (**inside, outside**) contour of the pipe and is then clamped into position for cutting.

d. Torch holders are designed with easy-to-read (**pre-set angles, protractors**) for precise control of the cutting angle.

e. A variation of the pipe beveling machine is a device that turns the pipe while the torch holder remains (**fixed, partially fixed**) instead of working around the pipe.

Objective 28

Complete statements about eye protection required for oxyacetylene cutting by circling the correct answers.

a. Wear (**a face shield, safety glasses**) when cleaning or chipping slag from base metal.

b. Wear (**safety glasses, safety glasses and a face shield**) when grinding joints or bevels.

c. Wear welding and cutting goggles to protect eyes from spatter, and choose goggles with a lens shade dark enough to protect eyes from (**heat burns, intense light rays**).

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 3
b. 4
c. 1
d. 5
e. 2

Objective 2

a. portable
b. relatively inexpensive
c. 3/16″
d. usually

Objective 3

a, c, d, e

Objective 4

a. acetylene
b. welding
c. oxygen

Objective 5

b, c, d, e, f

Objective 6

a. 2
b. 1
c. 2

Objective 7

a. 9
b. 8
c. 6
d. 3
e. 5
f. 1
g. 2
h. 4
i. 7

Objective 8

a. 1
b. 2
c. 3
d. 4
e. 5
f. 6
g. 7
h. 8

Objective 9

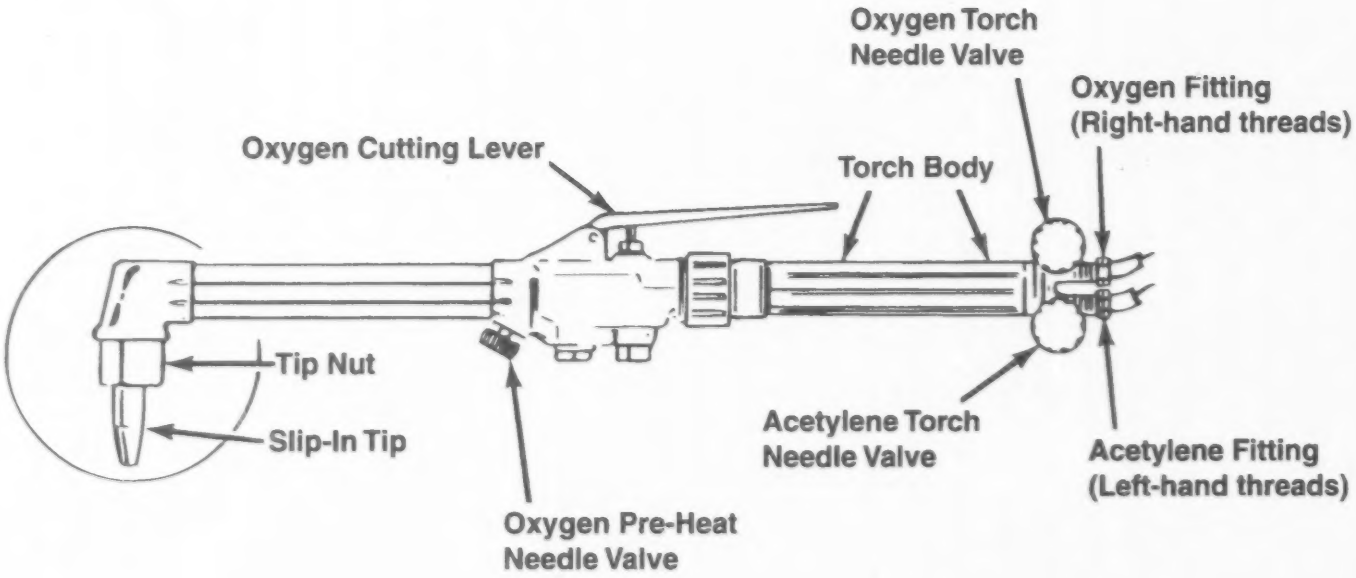
c, d, e

Answers to Written Test

Objective 10	a. Rosebuds b. Center c. Round d. Extension tube e. Slotted f. Raised
Objective 11	a. 3 b. 2
Objective 12	b, c, d
Objective 13	a. 3 b. 1 c. 2
Objective 14	b, c
Objective 15	a
Objective 16	a. 1 b. 4 c. 2 d. 3
Objective 17	a. Immediately b. Blowholes are; blowholes 1. Before 2. The original cutting line c. Fly in all directions
Objective 18	a, c
Objective 19	a. 2 b. 3 c. 1
Objective 20	a. Square b. Vertical and clean c. Bottom
Objective 21	a. 1 b. 1 c. 2 d. 1 e. 2

Objective 22	a. All the b. Shielding screens c. Slag d. Explode e. Can fly long distances f. Wastes g. Any container h. Gas cylinders
Objective 23	a, d, e
Objective 24	a, c, d
Objective 25	a, b, c
Objective 26	a, b, d
Objective 27	a. Pipe b. Manually operated or motorized c. Outside d. Protractors e. Fixed
Objective 28	a. A face shield b. Safety glasses and a face shield c. Intense light rays

Parts of an Equal-Pressure Cutting Torch



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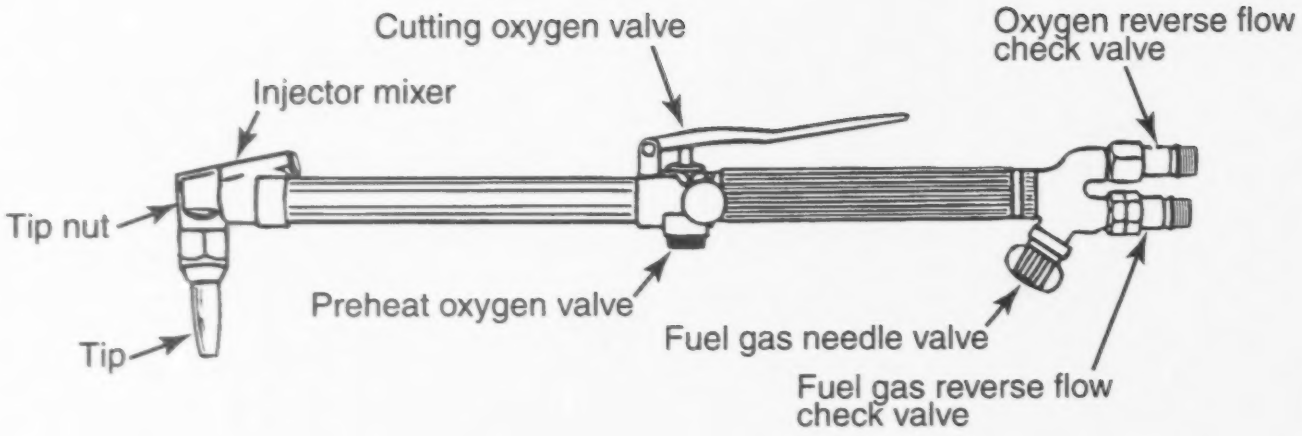
Parts of an Injector Cutting Torch



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Cutting Tip Data Chart

Metal Thickness	Tip Size	Regulator Pressure PSI		
		Acetylene	Other Fuel Gases	Oxygen
1/8″	000	6	10-11	23
3/16″	00	6	10-11	23
1/4″	0	7	10-11	33
3/8″	0	7	10-11	40
1/2″	1	7	10-11	40
5/8″	1	7	10-11	45
3/4″	2	7	10-11	40
1″	2	7	10-11	45
1 1/4″	2	7	10-11	55
1 1/2″	3	8	10-11	50
2″	3	8	10-11	55
2 1/2″	4	8	10-11	45
3″	4	8	10-11	50
4″	4	8		60
5″	5	9		60
6″	5	9		70
8″	5	9		80

Courtesy Smith Welding Equipment

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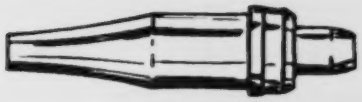
Typical Cutting Tips and Orifices

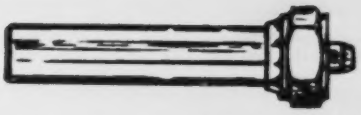


Light Preheat, Light Cutting

Acetylene

Medium Preheat, Light Cutting

Acetylene

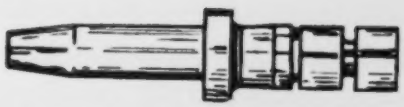


Heavy Preheat, Heavy Cutting

Acetylene

Medium Preheat, Gouging/Scarfing

Acetylene



General Purpose

Propane

General Purpose

Natural Gas (Methane)

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Unit Contents

Teacher Components

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* Job Sheets

1—Weld a Stringer Bead With a Bronze Rod on Steel Plate 61
2—Braze Weld a Square Groove Butt Joint in the Flat Position .. 65
3—Braze Weld a Lap Joint in the Horizontal Position 69
4—Repair a Worn Tool With Hardfacing 73

* The Job Sheets are located in the Student Workbook

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.

Suggested Activities

- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Talk to students about the added job opportunities for multi-talented welders. Braze welding, bronze surfacing, and hardfacing are full time jobs for some welders, but certain jobs demand these skills on an "as needed" basis. The welder with skills versatility always gets the better jobs.

- As with all welding processes, preparation is important. Use Objective 6 to address precoating for braze welding and the importance of proper use of flux as presented in Objective 7. Joint preparation as covered in Objective 10 should be stressed.

- Hardfacing is another process that requires special skills. It is frequently one of those "as needed" skills in many welding facilities. Use Objectives 21 and 22 to demonstrate the importance of hardfacing alloys and hardfacing powders.

- Preparation is a critical part of hardfacing. Stress this in Objective 24 that discusses maching requirements for surfaces to be hardfaced and again in Objective 25 with concerns about preheating and cooling.

- Job Sheet 4 permits students to hardface a worn tool. Select worn plowshares for this activity if you can find enough of them. Otherwise select a variety of tools and have students experiment with preparation and actual hardfacing. Be sure to have students identify the type of wear the worn tool has been subjected to.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.

- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.

- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

Sample A

4—**Skilled**—Can perform job with no additional training.
3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
1—**Unskilled**—Is familiar with process, but is unable to perform job.
0—**No exposure**—No information or practice provided during training program.

Sample B

Yes—Can perform job with no additional training.
No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- Connor, Leonard P., ed. *Welding Handbook, Eighth Ed., Vol. 1, Welding Technology.* Miami, FL: American Welding Society, 1989.
- Oates, William R., ed. *Welding Handbook, Eighth Ed., Vol. 3, Materials Applications Part 1.* Miami, FL: American Welding Society, 1996.
- *Welding Fabrication & Date Book 1988/89.* Cleveland, OH: Penton Publishing, Inc., 1988.

Suggested Activities

Suggested Supplemental Resources

Print Media

- *Brazing Handbook*. Miami, FL: American Welding Society, 1991.

  This 493-page text is a truly comprehensive document with 33 chapters, 200 figures, many of them in color, and step-by-step procedures for brazing activities. This text originally sold for $65, but is available now for only $5 because of a printing overrun. Order from:

  The American Welding Society at 1-800-334-9353.
  Internet: http://www.aws.org

  Other brazing materials from the American Welding Society include:

- *Specifications for Torch Brazing*, 18 pages, 1999.

- *Specifications for Aluminum Brazing*, 20 pages, 1999.

  The American Welding Society at 1-800-334-9353.
  Internet: http://www.aws.org

Written Test

Name _____

Date _____ Score_____

Objective 1

Match the terms with their definitions. Write the correct numbers in the blanks provided.

1. Hardfacing
2. Oxidizing flame
3. Carburizing flame
4. Machining
5. Flux
6. Precoating
7. Oxidation

_____ a. A flame with more acetylene than a neutral flame

_____ b. A material used to hinder or prevent the formation of oxide and other undesirable substances in molten metal and on solid metal surface, and to dissolve or otherwise facilitate the removal of such substances

_____ c. A surfacing variation in which surfacing material is deposited to reduce wear

_____ d. Mechanically grinding or milling surfaces, edges, and corners to precise dimensions of a workpiece to be welded; finishing a workpiece after welding

_____ e. The chemical reaction of a metal with oxygen in the air in a process that promotes contamination of metal surfaces and eventually leads to rust

_____ f. A flame with more oxygen than a neutral flame

_____ g. Coating the base metal in a joint by dipping, electroplating, or other means prior to soldering or brazing

Objective 2

Differentiate between the definitions of *fusion welding* and *braze welding*. Place an "F" beside the definition of fusion welding and a "B" beside the definition of braze welding.

_____ a. The filler rod has a melting point approximately the same as the melting point of the base metal, and both the filler metal and the base metal are melted and fused together.

_____ b. The filler rod has a melting point below the melting point of the base metal, the base metal is never melted, and the weld is formed as a result of gravity pull resulting from weld design.

Written Test

Objective 3

Differentiate between the definitions of *brazing* and *braze welding*. Place a "B" beside the definition for brazing and a "W" beside the definition of braze welding.

_____ a. The filler metal must have a melting point above 840°F, but lower than the melting point of the base metal, and the filler metal is drawn into a tight-fitting joint by capillary attraction.

_____ b. The filler metal must have a melting point above 840°F, but lower than the melting point of the base metal, and the filler metal is deposited into the joint by gravity pull in the joint design, not by capillary attraction.

Objective 4

Select true statements about the advantages of braze welding by placing an "X" in the blanks next to the true statements.

_____ a. Braze welding is almost as fast as fusion welding because the heat input required is less.

_____ b. Braze welding saves time and reduces fuel gas consumption.

_____ c. Braze welding eliminates preheating requirements.

_____ d. The reduction of heat input in braze welding has special advantages for welding cast iron because the extremely ductile filler metal can absorb stresses as it cools.

_____ e. Because of a reduction in contraction and expansion, braze welding on steel reduces distortion of the base metal.

_____ f. Braze welding can be used to join dissimilar metals that cannot be fusion welded.

Objective 5

Select true statements about the limitations of braze welding by placing an "X" in the blanks next to the true statements.

_____ a. In braze welding, the weld color cannot match the base metal.

_____ b. Because there are no filler rods for special applications, braze welding cannot be used on metal and joints where high stress is a factor.

_____ c. A braze weld will lose its strength at temperatures above 300°F.

_____ d. A braze weld may have corrosion-resistant properties different from those of the base metal.

_____ e. The strength of a braze weld is limited to the strength of the filler metal.

Objective 6

Complete statements about precoating in braze welding by circling the correct answers.

a. Braze welding is based on the principle that (**brass and bronze, tin and zinc**) when raised to the proper temperature will melt and form a smooth precoating film on the surface of a properly prepared and heated joint.

b. Precoating cannot be properly accomplished unless the joint has been thoroughly (**cleaned, heated**) and properly prepared.

c. Good precoating requires a (**neutral to slightly reducing, neutral to slightly carburizing**) flame.

d. Precoating requires a (**steady hand, good brazing flux**).

e. Improper precoating action is almost always caused by (**underheating, overheating**) the base metal.

Objective 7

Select true statements about the purposes of flux by placing an "X" in the blanks next to the true statements.

_____ a. Flux chemically cleans the base metal.

_____ b. Flux prevents oxidation of the filler metal.

_____ c. Flux floats and removes the oxides already present.

_____ d. Flux shows the flow of the filler metal.

_____ e. Flux increases the ability of the filler metal to adhere to the base metal.

_____ f. Flux brings the filler metal into immediate contact with the metals being jointed.

_____ g. Flux permits the filler metal to penetrate the pores of the base metal.

Objective 8

Complete statements about the characteristics of filler rods for braze welding by circling the correct answers that best completes each statement.

a. Filler rods consist of copper alloys containing about (**60 percent copper and 40 percent zinc, 60 percent copper and 40 percent brass**), which:

- Produce a high (**tensile, shear**) strength.
- Increase (**ductility, malleability**).

b. Filler rods contain small quantities of tin, iron, manganese, and (**silicon, aluminum**) which help to:

- Deoxidize the (**weld metal**, **welding rod**).
- Decrease the tendency to (**fume**, **overheat**).
- Increase the free-flowing action of the (**molten metal**, **welding rod**).
- Increase the hardness of the deposited metal for greater (**wear resistance**, **adherence**).

c. Filler rods should be cleaned with (**emery cloth**, **a file**) before use.

Objective 9

Complete statements about important factors in successful braze welding by circling the number of the information that best completes each of the following statements.

a. Successful braze welding really starts with:

1. Good equipment
2. Careful planning
3. Cleaning and properly preparing a joint.

b. Proper precoating is achieved through the cleaning action of the flux and by:

1. Good torch and rod manipulation.
2. Maintaining proper metal temperature.
3. Selecting the proper rod.

c. When a weld is made in two or more passes, the result to inspect for is:

1. Complete fusion between layers of filler metal.
2. A flux-free weld.
3. Adherence with the base metals.

Objective 10

Select true statements about techniques used in preparing joints for braze welding by placing an "X" in the blanks next to the true statements.

_____ a. Generally prepare joints for braze welding the same as for fusion welding base metals of like thickness.

_____ b. When braze welding base metal no thicker than 1/8˝ to 3/16˝, you may use beveled edges.

111

_____ c. When braze welding metals thicker than 3/16″, use square edges.

_____ d. In all cases, clean thoroughly every part of the base metal to be precoated until it is completely free of rust, scale, oil, and grease.

_____ e. Whenever possible, clean base metal at least 1/2″ back from the edge of the joint.

Objective 11

Complete statements about techniques used to remove oxides in preparing joints for braze welding by circling the correct answers that best completes each of the following statements.

a. Remove oxides mechanically with a (**torch, wire brush or portable grinder**) or chemically with a suitable (**powder, flux**).

b. Sometimes, to achieve a thorough cleaning of the joint, you must use (**machining, both chemical and mechanical methods**).

Objective 12

Complete statements about techniques used for braze welding and cast iron by circling the number of the information that best completes each of the following statements.

a. A welding tip for braze welding steel and cast iron should be:

1. One size smaller than a tip selected for fusion welding a metal of equal thickness.
2. One size larger than a tip selected for fusion welding a metal of equal thickness.

b. For braze welding, the torch should be adjusted to:

1. A neutral to slightly carburizing flame.
2. A neutral to slightly reducing flame.

c. Preheating for braze welding calls for moving the torch back and forth over a generous area of the base metal until it begins to:

1. Turn bright red.
2. Glow dull red.

d. In braze welding, after proper preheat, the end of the filler rod should be heated and:

1. Placed immediately on the joint.
2. Dipped in flux.

e. The temperature is just right for braze welding when:

1. The melted bronze flows smoothly over a large area of the base metal.
2. The bronze drops off in uniform quantities onto the base metal.

Objective 13

Match braze welding problems with their causes by circling the number of the information that best completes each of the following statements.

a. When the molten bronze forms into drops, it means:

1. The base metal is too hot.
2. The base metal is not yet hot enough.

b. When the molten bronze tends to bubble and boil, it means:

1. The base metal is too hot.
2. The base metal is not yet hot enough.

Objective 14

Differentiate between the definitions of surfacing and hardfacing. Place a "B" beside the definition of *bronze surfacing* and an "H" beside the definition of *hardfacing*.

_____ a. Braze-welding technique used to rebuild or resurface worn parts

_____ b. Welding process used to deposit specialized alloys onto parts subject to extensive wear so that the parts become more resistant to abrasion, corrosion, impact, and high temperature

Objective 15

Select true statements about the advantages of bronze surfacing by placing an "X" in the blanks next to the true statements.

_____ a. When bronze is applied to steel or cast iron parts subject to sliding friction, the reconditioned parts sometimes give longer service than brand new parts.

_____ b. When large pistons have to be replaced, the cost of bronze surfacing is only slightly more than the cost of a new piston, and pistons rebuilt in this way will sometimes outlast new pistons.

_____ c. Cast iron gears can be rebuilt faster at less cost with bronze welding than with oxyacetylene or arc welding.

Objective 16

Complete statements about limitations of bronze welding by circling the correct answers that best completes the following statements.

a. Bronze surfacing should not be used on parts such as (**superheated steam engine pistons, high torque turbine blades**) that will be subjected to temperatures above 500°F.

b. Bronze surfacing should not be used on parts such as (**piston rods, valves**) that will be subjected to alternating tensile and compressive stresses.

Objective 17

Differentiate between methods preparing new and cast iron surfaces for bronze surfacing by placing an "X" in the blanks next to the true statements that tell how to prepare cast iron surfaces for bronze surfacing.

_____ a. These surfaces should be machined or ground, or in some cases, just thoroughly cleaned before bronze is applied.

_____ b. These surfaces, should be ground or sand blasted because machining could leave graphite smears that make proper precoating difficult.

Objective 18

Select true statements about guidelines for bronze surfacing by placing an "X" in the blanks next to the true statements.

_____ a. Remember that bronze surfacing is essentially a hardfacing process.

_____ b. When preheating a cast iron part, don't isolate the flame in one spot too long, but move the flame around to distribute heat evenly and avoid cracking the cast iron.

_____ c. When preheating steel, avoid excessive heat build-up in one area or the part could be permanently distorted.

_____ d. Use a neutral or slightly carburizing flame and a good brazing flux.

_____ e. To avoid variances in quality, plan the application so that the job can be completed without interruption.

_____ f. Keep the layer of bronze just thick enough so that the lowest spots will still require some finish machining.

_____ g. Always allow the part to cool slowly to room temperature before machine finishing.

Objective 19

Select true statements about guidelines for hardfacing applications by placing an "X" in the blanks next to the true statements.

_____ a. Hardfacing is usually confined to only that portion of a part that is subject to critical wear, not the entire part.

_____ b. Hardfacing is frequently used on surface areas, edges, or points that are subjected to contact or impact wear.

_____ c. Hardfacing is usually applied over a base metal selected for general strength and economy, but hardfacing alloys are selected for specific wearing conditions.

Written Test

Objective 20

Match hardfacing alloys with their definitions. Write the correct numbers in the blanks provided.

1. Cobalt-base and nickel-base alloys
2. Low-alloy, iron-base alloys
3. Tungsten-carbide alloys
4. High-alloy, iron-base alloys

_____ a. Materials that are alloyed up to 12 percent with chromium, molybdenum, or manganese

_____ b. Materials with 12 to 50 percent alloy content of chromium and sometimes nickel and cobalt

_____ c. Materials that contain a small amount of iron, usually cobalt-chromium-tungsten alloys that are expensive but have high resistance to corrosion and oxidation.

_____ d. Materials that combine the qualities of hardness and brittleness required to make manufacturing tools.

Objective 21

Complete statements about hardfacing powders and their characteristics by circling the correct answers that best completes each of the following statements.

a. Powders are used primarily on (**thick, thin**) base metals that cannot tolerate the heat of conventional arc or oxyacetylene hardfacing.

b. Powders produce deposits so (**smooth, strong**) that some parts can be returned to service with no additional machining.

c. Powders may be sprayed on with a spray gun or a hand-held torch assembly, and torch grade powders usually have an improved (**wetting, cleaning**) action.

d. Powders range from nickel-base alloys for (**cast iron, general**) use to cobalt-based alloys where nickel cannot be used.

e. Powders are normally fused onto the base metal with a (**reducing, carburizing**) flame after preheating to 600°F.

Objective 22

Complete statements about the advantages of hardfacing with an oxyacetylene torch by circling the number of the information that best completes each of the following statements.

a. Since more pounds per hour can be deposited with arc welding, it would seem that hardfacing with an oxyacetylene flame would not have an advantage, but yet:

1. The oxyacetylene flame is faster.
2. The oxyacetylene flame does not require learning arc welding skills.
3. The oxyacetylene flame holds dilution of the hardfacing alloys to a minimum.

b. One special advantage that oxyacetylene has over arc hardfacing is that:

1. Oxyacetylene is very portable.
2. Oxyacetylene can deposit alloys in minimal thicknesses to save expensive materials, and arc welding processes that can do this are very expensive.
3. Oxyacetylene is by far the least expensive process.

Objective 23

Complete statements about guidelines for preparing surfaces for hardfacing by circling the correct answers that best completes each of the following statements.

a. Thoroughly clean surfaces so that they are free of oxides, dirt, oil, or (**any foreign substance, slag**).

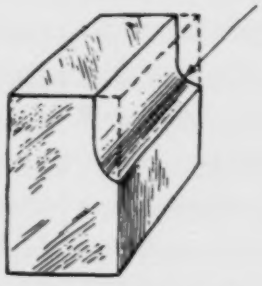
b. Because hardsurfacing applications are limited to (**only edges, specific sections of a part**), you must almost always grind or machine a surface.

c. (**Grind, Round off**) all sharp corners.

Objective 24

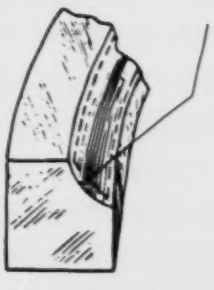
Identify requirements for machining surfaces to be hardfaced. Circle the number of the information that best describes the machining required in each of the following illustrations.

a.



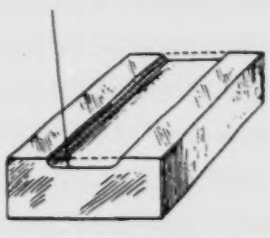
1. An edge or corner joint that will be subjected to shock should be prepared as illustrated.
2. A corner that will be subjected to heavy impact should be prepared as illustrated.

b.



1. An edge or corner that will be subjected to heavy impact should be prepared as illustrated.
2. An edge or a corner that will not be subjected to heavy impact should be prepared as illustrated.

c.



1. Longitudinal areas such as rolling guides should be prepared as illustrated.
2. A stress area subject to abrasive friction should be prepared as illustrated.

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Objective 25

Select true statements about preheating and cooling requirements for hardfacing by placing an "X" in the blanks next to the true statements.

_____ a. Some degree of preheating is required in almost all hardfacing applications.

_____ b. Larger parts must be fully preheated either with a torch or in a preheating furnace.

_____ c. Parts should not be overheated or oxides may form on the surface.

_____ d. Preheating should be applied evenly to avoid surface cracking in cooling.

_____ e. After hardfacing the part should be cooled rapidly, and this is an extremely important factor in the process.

Objective 26

Complete statements about techniques used for oxyacetylene hardfacing by circling the number of the information that best completes each of the following statements.

a. After preheating, the torch should be held about 1/8" from the surface, and then the torch should be held still until:

1. The surface turns dull red.
2. The surface turns bright red.
3. The surface sweats and gives a glazed appearance.

b. When hardfacing starts, as the end of the rod melts and forms a puddle on the surface, if the puddle does not spread out uniformly on the surface it means:

1. You picked the wrong welding rod.
2. The metal was improperly cleaned.
3. The metal needs more preheating.

c. If the first drops spread uniformly, the rod should then be withdrawn form the flame, and then:

1. Move the torch slightly left or right and reinsert the rod.
2. Direct part of the flame on the puddle, and part on the surrounding base metal to spread the alloy farther.
3. Put the rod slowly back into the flame.

Written Test

Objective 27

Select true statements about techniques for making a second pass when oxyacetylene hardfacing. by placing an "X" in the blanks next to the true statements.

_____ a. After the first pass is completed, the surface will not sweat, so a second pass requires special attention.

_____ b. Move the puddle by rod action, not with flame pressure.

_____ c. Work toward the hand holding the rod, using the forehand technique.

_____ d. When oxides or particles of dirt appear on the surface, try to float them to the surface with the flame, and use the rod to remove particles only when flame action doesn't get the job done.

_____ e. Cool the part rapidly after the final pass is complete.

_____ f. Finish grinding or machining the part to specifications.

Objective 28

Complete statements about safety precautions used for hardfacing by circling the number of the information that best completes each of the following statements.

a. Some fluxes that contain fluorine compounds can become toxic when vaporized, and that's why:

1. You should always wear a respirator.
2. The hardfacing workplace should be well ventilated.
3. Fluxes with fluorine compounds should never be used.

b. Some steels that have a white coating and other steels that turn yellow-gold when heated pose the possibility that dangerous fumes might be generated with the vaporization of

1. Magnesium in the steel.
2. Nickel alloys in the steel.
3. Cadmium in the steel.

c. The basic rule for using a vapor degreaser for cleaning metal to be hardfaced is to:

1. Always apply the degreaser with a clean rag.
2. Make sure that the cleaner has dried and that all the fumes have evaporated.
3. Dilute the degreaser with a common household detergent.

*Permission to duplicate this test is granted.

Answers to Written Test

Objective 1

a. 3
b. 5
c. 1
d. 4
e. 7
f. 2
g. 6

Objective 2

a. F
b. B

Objective 3

a. B
b. W

Objective 4

b, d, e, f

Objective 5

a, b, d, e

Objective 6

a. Brass and bronze
b. Cleaned
c. Neutral to slightly reducing
d. Good brazing flux
e. Overheating

Objective 7

a, b, c, e, f, g

Objective 8

a. 60 percent copper and 40 percent zinc
   - Tensile
   - Ductility

b. Silicon
   - Weld metal
   - Fume
   - Molten metal
   - Wear resistance

c. Emery cloth

Objective 9

a. 3
b. 2
c. 1

Objective 10

a, d, e

Objective 11

a. Wire brush or portable grinder; flux
b. Both chemical and mechanical methods

Answers to Written Test

Objective 12	a. 1 b. 2 c. 2 d. 2 e. 1
Objective 13	a. 2 b. 1
Objective 14	a. B b. H
Objective 15	a, c
Objective 16	a. Superheated steam engine pistons b. Piston rods
Objective 17	b
Objective 18	b, c, e, f, g
Objective 19	a, b, c
Objective 20	a. 2 b. 4 c. 1 d. 3
Objective 21	a. Thin b. Smooth c. Wetting d. General e. Reducing
Objective 22	a. 3 b. 2
Objective 23	a. Any foreign substance b. Specific sections of a part c. Round off
Objective 24	a. 1 b. 2 c. 1

Objective 25	a, b, c, d
Objective 26	a. 3 b. 3 c. 2
Objective 27	a, c, d, f
Objective 28	a. 2 b. 3 c. 2

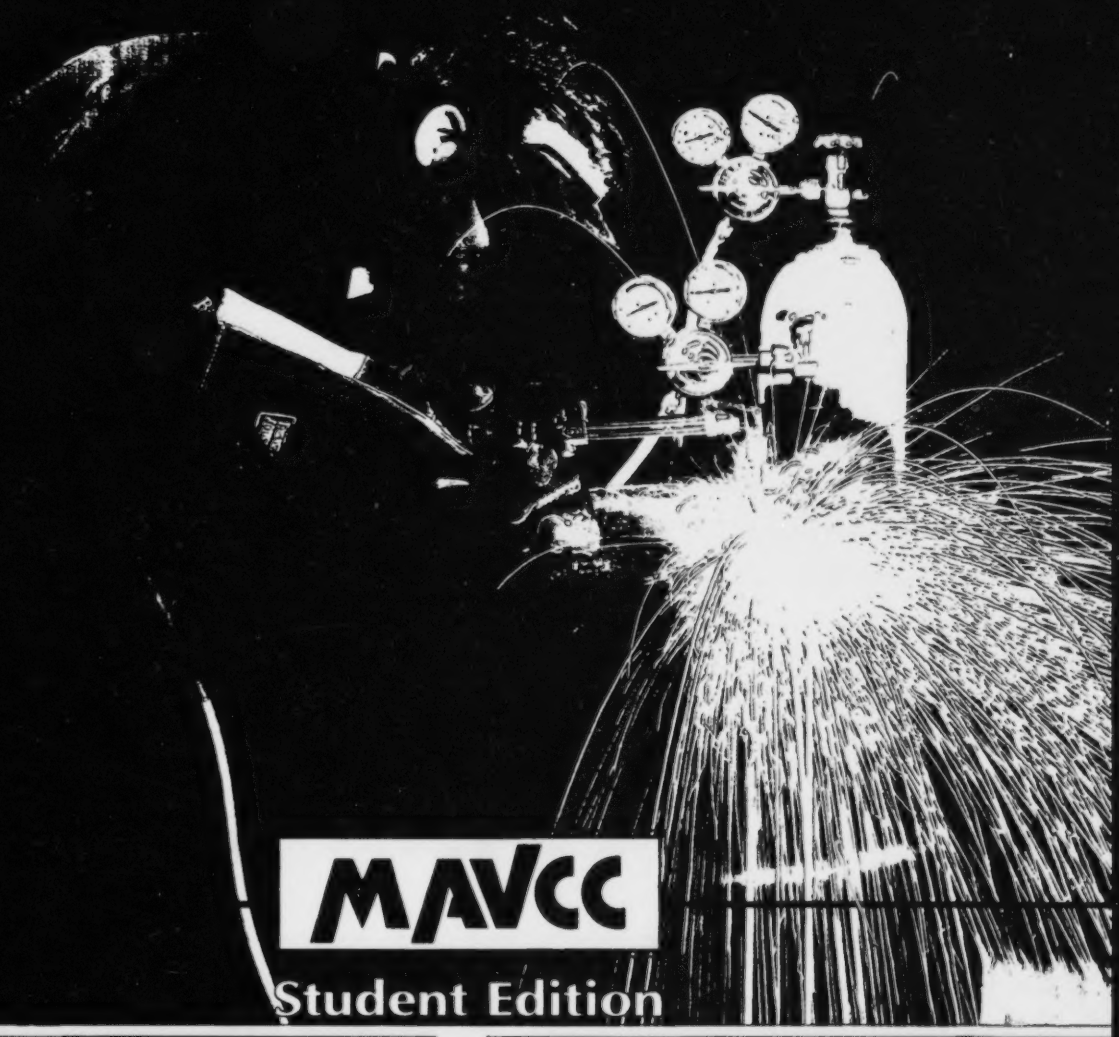
Metals Preheating Chart

METAL GROUP	METAL DESIGNATION	C.	RECOMMENDED PREHEAT
PLAIN CARBON STEEL	Plain Carbon Steel	Below .20	Up to 200°F
	Plain Carbon Steel	.20 - .30	200°F - 300°F
	Plain Carbon Steel	.30 - .45	300°F - 500°F
	Plain Carbon Steel	.45 - .80	500°F - 800°F
CARBON MOLY STEELS	Carbon Moly Steel	.10 - .20	300°F - 500°F
	Carbon Moly Steel	.20 - .30	400°F - 600°F
	Carbon Moly Steel	.30 - .35	500°F - 800°F
MANGANESE STEELS	Silicon Structural Steel	.35	300°F - 500°F
	Medium Manganese Steel	.20 - .25	300°F - 500°F
	SAE T 1330 Steel	.30	400°F - 600°F
	SAE T 1340 Steel	.40	500°F - 800°F
	SAE T 1350 Steel	.50	600°F - 900°F
	12% Manganese Steel	1.25	Usually Not Required
HIGH TENSILE STEELS	Manganese Moly Steel	.20	300°F - 500°F
	Manten Steel	.30 Max.	400°F - 600°F
	Armco High Tensile Steel	.12 Max.	Up to 200°F
	Double Strength #1 Steel	.12 Max.	300°F - 600°F
	Double Strength #1A Steel	.30 Max.	400°F - 700°F
	Cr-Cu-Ni Steel	.12 Max.	200°F - 400°F
	Cr-Mn Steel	.40	400°F - 600°F
	Hi-Steel	.12 Max.	200°F - 500°F
NICKEL STEELS	SAE 2015 Steel	.10 - .20	Up to 300°F
	SAE 2115 Steel	.10 - .20	200°F - 300°F
	2½% Nickel Steel	.10 - .20	200°F - 400°F
	SAE 2315 Steel	.15	200°F - 500°F
	SAE 2320 Steel	.20	200°F - 500°F
	SAE 2330 Steel	.30	300°F - 600°F
	SAE 2340 Steel	.40	400°F - 700°F

TM 1

Oxyacetylene Welding and Oxyfuel Cutting

THIRD EDITION



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Student Edition

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Oxyacetylene Welding and Oxyfuel Cutting

Third Edition

Student Edition

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Information Sheet 1–7

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2—Lay Beads on Flat Plate with No Filler Rod 7
3—Lay Beads on Flat Plate with Filler Rod 11
4—Weld an Outside Corner Joint in the Flat Position 15
5—Weld a Square-Groove Butt Joint in the Flat Position 19
6—Weld a Lap Joint in the Flat Position 23
7—Weld a T-Joint in the Flat Position 27

* The Job Sheets are located in the Student Workbook

Prerequisites:
None

Learning Activities Sheet

Student Name _____

Place a checkmark in the appropriate box as you complete each of the steps below.

❑	1. **Take**	Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.
❑	2. **Read**	Objective Sheet.
❑	3. **Study**	Information Sheet, Objectives 1 through 21.
❑	4. **View**	Videotape entitled "Oxyacetylene Welding Techniques."
❑	5. **Observe**	Demonstration of procedures to be used in completing Job Sheet 1.
❑	6. **Do**	Job Sheet 1, "Light, Adjust, and Shut Down an Oxyacetylene Welding Torch in Compliance with Safety Standards."
❑	7. **Stop**	Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 8. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 1 and do it again.
❑	8. **Do**	Job Sheet 2, "Lay Beads on Flat Plate With No Filler Rod," Job Sheet 3, "Lay Beads on Flat Plate With Filler Rod," Job Shee 4, "Weld and Outside Corner Joint in the Flat Position," Job Sheet 5, "Weld a Square-Groove butt Joint in the Flat Position," Job Sheet 6, (Weld a Lap Joint in the Flat Position," and Job Sheet 7, "Weld a T-Joint in the Flat Position."
❑	9. **Stop**	After completing each job sheet, have instructor evaluate your performance and if the evaluation is satisfactory, continue to the next job sheet. If the performance is not satisfactory, study the procedure in that job sheet, and redo the job sheet. After satisfactorily completing all the job sheets, continue to step 10.
❑	10. **Check**	With instructor for any additional assignments to be completed.

❑	11. **Do**	Additional assignments listed below. _____ _____
❑	12. **Take**	Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.
❑	13. **Stop**	Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Objective Sheet

Unit Objective

After completing this unit, the student should be able to safely light, adjust, and shut down an oxyacetylene system, run beads on flat plate with and without filler metal, and weld butt joints, lap joint, T-joints, and corner joints. The student should demonstrate these competencies by completing the job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to oxyacetylene welding with their correct definitions.
2. Select true statements about benefits of learning oxyacetylene welding and cutting.
3. Complete a list of equipment needed for oxyacetylene welding.
4. Complete statements about safety rules for the oxyacetylene workplace.
5. Select solutions for personal safety requirements.
6. Complete statements about eye protection required for oxyacetylene welding.
7. Solve problems about pressure regulating valves.
8. Differentiate between welding hoses and their characteristics.
9. Complete statements about parts of a welding torch.
10. Solve problems about types of mixers and their purposes.
11. Select true statements about welding tips and their uses.
12. Solve problems about basic safety rules for oxyacetylene cylinders and gases.
13. Complete a chart of oxyacetylene flame characteristics and uses.
14. Select true statements about guidelines for flame adjustment.
15. Complete statements about causes and detection of backfire and flashback.
16. Complete statements about ways to control backfire and flashback.
17. Complete statements about welding tip selection.

Objective Sheet

18. Complete statements about filler rod selection, handling, and safety.
19. Select true statements about AWS designations for iron and steel gas welding rods.
20. Select true statements about flux selection, handling, and safety.
21. Identify welding positions.
22. Identify basic types of welds and their AWS symbols.
23. Identify basic welding joints and positions.
24. Solve problems about elements of good fusion welding.
25. Select true statements about rules of thumb for rod and torch angles.
26. Select true statements about guidelines for using the forehand technique in fusion welding.
27. Select true statements about guidelines for using the backhand technique in fusion welding.
28. Complete statements about techniques for controlling flame and rod motion.
29. Select true statements about guidelines for preheating, interpass, and postheating.
30. Select correct procedures for cleanup, inspection, and testing.
31. Arrange in order the steps in setting up cylinders and regulators.
32. Select true statements about steps in purging oxygen and fuel gas regulators.
33. Select correct procedures for final steps in setting up oxyfuel equipment.
34. Light, adjust, and shut down an oxyacetylene welding torch in compliance with safety standards. (Job Sheet 1)
35. Lay beads on flat plate with no filler rod. (Job Sheet 2)
36. Lay beads on flat plate with filler rod. (Job Sheet 3)
37. Weld an outside corner joint in the flat position. (Job Sheet 4)
38. Weld a square-groove butt joint in the flat position. (Job Sheet 5)
39. Weld a lap joint in the flat position. (Job Sheet 6)
40. Weld a T-joint in the flat position. (Job Sheet 7)

Information Sheet

Objective 1

Terms and definitions

a. **Base metal**—Metal to be welded, brazed, or cut

b. **Fusion welding**—A welding process that joins metals by heating them to a melting point and allowing them to fuse or flow together

c. **Gap wire**—A wire used for correct spacing of butt joints

d. **Interpass heating**—Application of heat to a base metal during a welding process

e. **Penetration**—Distance from the original surface of the base metal to that depth at which fusion stops

f. **Postheating**—Heating after a welding operation to provide uniform cooling and stress relief

g. **Preheating**—Heating prior to a welding or cutting operation

h. **Stress relief**—A process whereby base metals are heated to even temperature below the critical range, held at that temperature for a given time, and uniformly cooled to avoid distortion, cracking, or other stress-related problems

i. **Tack weld**—A short weld used to temporarily hold workpieces in place

j. **Welding positions**—A numbered reference to the physical positioning of a workpiece with 1 as flat, 2 as horizontal, 3 as vertical, and 4 as overhead

Objective 2

Benefits of learning oxyacetylene welding and cutting

a. Teaches methods used in forming, recognizing, and controlling a weld puddle

b. Teaches methods of properly holding and manipulating welding equipment and develops techniques that are useful in other welding processes

c. Provides practice leading to good eye-hand coordination required in the welding trade

d. Teaches the basics of metallurgy and the characteristics of metals being welded or cut

e. Provides a familiarity with the welding workplace and its activities

f. Teaches a welding skill that will increase employability when facing job demands that require both arc and oxyacetylene skills

Information Sheet

Objective 3

Equipment required for oxyacetylene welding

a. Oxygen cylinder

b. Acetylene cylinder

c. Pressure regulator for oxygen

d. Pressure regulator for acetylene

e. Two hoses encased together

f. Welding torch with assorted tips

g. Welding goggles and safety glasses

h. Sparklighter

i. Check valves to prevent flashback

> **Caution:** Never use a welding or cutting torch that does not have check valves.

j. Cylinder wrench

k. Chipping hammer and wire brush

Objective 4

Safety rules for the oxyacetylene workplace

a. Keep work area free of grease, oil, and flammable materials because flying sparks can fly for several feet and cause a fire.

b. Cool or quench hot metal and extinguish all sparks before leaving the work area, but do not quench during a welding process.

c. Do not leave torches, tips, or hot metal where they can be accidentally touched by a co-worker or visitor.

d. Never carry matches or lighters filled with butane or propane into any work area where any kind of welding or cutting is taking place.

e. Do not withdraw too much volume at one time from an acetylene tank because a high demand of acetylene could withdraw acetone from the cylinder and create a hazardous condition.

Note: Two or more acetylene cylinders can be manifolded together to provide high flow rates.

Objective 5

Personal safety requirements

a. **Shirts**—Keep collar and sleeves buttoned to keep out sparks and remove pockets from front of shirt or tape them shut if they don t have pocket flaps

b **Pants**—Should have no cuffs and be long enough to come down over shoe tops

> **Caution:** Clothes made of polyesters and other synthetics catch fire easily so it's better to wear wool or heavily-starched cottons, and frayed clothing of any kind is dangerous.

c. **Welding cap**—Should be worn to protect hair from sparks and spatter

> **Caution:** Some hair sprays are highly flammable and can be ignited by sparks, and any kind of plastic hair cap or covering is dangerous in the welding area.

d. **Shoes**—Should have high tops of tough leather, and steel toes are recommended

> **Caution:** Never wear sneakers, tennis shoes, or loafer-type shoes when welding.

e. **Gloves**—Should be leather with gauntlets

> **Caution:** Use pliers or another suitable tool for handling hot metal because good welding gloves are expensive and it's foolish to burn them up because of bad work habits.

f. **Safety glasses**—Should be worn under helmets and goggles

Objective 6

Eye protection required for oxyacetylene welding

a. Wear safety glasses when cleaning or chipping base metals.

b Wear safety glasses and a face shield when grinding joints or bevels.

c. Wear welding goggles to protect eyes from spatter, and choose goggles with a lens shade dark enough to protect eyes from radiation burns.

Type of Welding	Metal Thickness	Shade #
Brazing	—	3
Light	up to 1/8"	4 or 5
Medium	1/8"–1/2"	5 or 6
Heavy	1/2" +	6 or 8

d. Play it safe and start with a lens too dark to see the work zone, then work down to a lighter shade that affords a good view of the work zone without straining your eyes.

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Information Sheet

Objective 7

Pressure regulating valves

a. Each regulator has two gauges mounted on a single manifold; one gauge indicates the cylinder pressure, the other indicates the working pressure for the torch.

Figure 1—Oxygen regulator

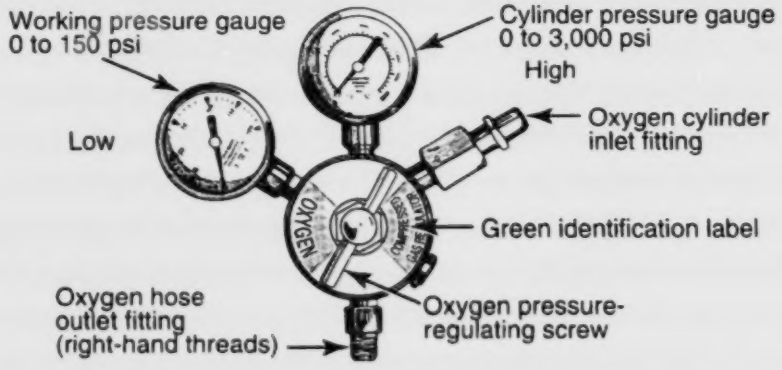
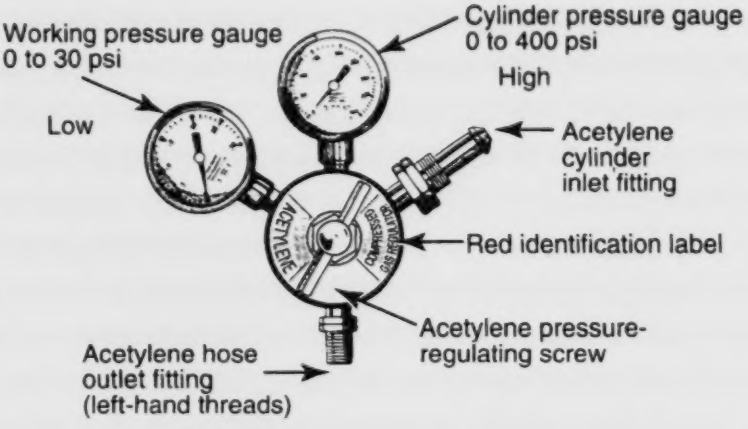


Figure 2—Acetylene regulator



b. Each regulator has an adjusting screw so pressure to the torch can be quickly controlled by turning the screw clockwise to increase pressure or counter-clockwise to decrease or completely shut off pressure.

Objective 8

Welding hoses and their characteristics

a. **Transport**—Special nonporous hoses are used to transfer the gases from the cylinders to the torch.

b. **Color**—Acetylene hoses are always red; oxygen hoses are usually green, but sometimes black.

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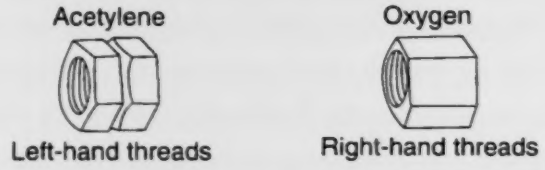
c. **Connector threads**—Acetylene connectors have a V-groove and left-handed threads, and oxygen connectors have plain surfaces and right-handed threads.

Figure 3



Note: The left-handed threads are to assure that the hoses can never be connected to the wrong cylinder.

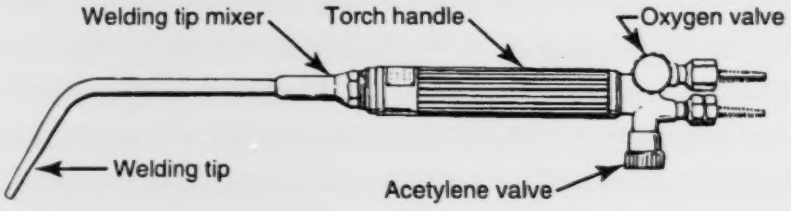
d. **New hoses**—New hoses are coated inside with a powder to provide storage protection; before use, the powder should be blown out by attaching each hose to the proper cylinder regulators, and opening the regulator to about five pounds of pressure.

Note: Complete the purging before you put a torch on the hoses.

Objective 9 **Parts of a welding torch**

a. The torch body is that part of a torch designed to be held; it contains two needle valves to control the flow of acetylene and oxygen.

Figure 4



b. The welding head is the torch component that contains a mixer or injector, the mixing throat, and the welding tip to control the flame.

Objective 10 **Types of mixers and their characteristics**

a. Equal-pressure mixers rely on positive control of both oxygen and fuel gas; in other words, the pressures are controlled at the regulators and enter the mixing chamber at controlled pressures.

b. Equal-pressure or "E" mixers allow an operator greater control of the oxyfuel ratio and are used where a very carburizing or oxidizing flame is required or in high-flow heating applications.

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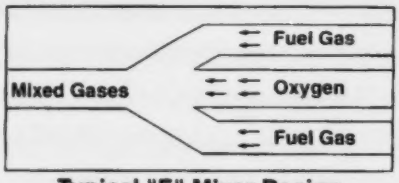
c. E mixers are primarily used with acetylene but can also be used with alternate fuels when positive pressure control of the fuel gas is available.

Figure 5



Typical "E" Mixer Design

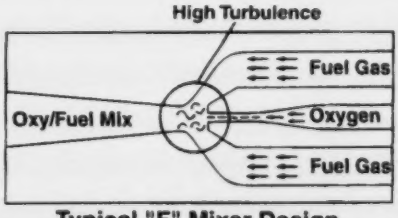
Courtesy Harris Calorific, Inc.

d. Injector mixers require that only the oxygen has a positive pressure control and the oxygen exits a chamber at a very high velocity which causes the fuel tas to be aspirated into the mixing chamber.

e. The high turbulence produced in the mixing chamber provides a more homogenous oxyfuel mixture and because of this superior mixing design, injector mixers tend to maximize BTU output.

f. Injector mixers ar ealso called "F" mixers and are frequently used with low pressure natural gas; they are recommended for use with other alternate fuels when maximum BTU output is desireable.

Figure 6



Typical "F" Mixer Design

Courtesy Harris Calorific, Inc.

Objective 11 **Welding tips and their uses**

a. Welding tips should be selected according to the metal thickness of the workpiece.

b. Tip sizes vary from 000 for use on 1/32" metal, up to a number 12, which can be used on metal from 3" to 4".

c. Replaceable elbow tips are one-piece tips that fit onto the torch body and provide long cone flame characteristics for general purpose welding and brazing.

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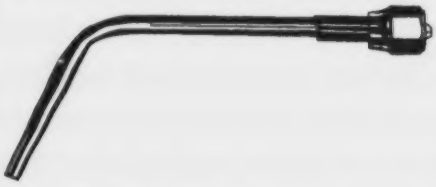
Figure 7



Courtesy Victor®

d. Other welding tips use replaceable welding tip ends that can be easily switched for working with oxy-propane or oxy-natural gas applications.

Figure 8

Courtesy Harris Calorific, Inc.

Objective 12 **Basic safety rules for oxyacetylene cylinders and gases.**

Note: These basic rules and illustrations are courtesy of Smith's Welding Equipment.

a. Secure cylinder in a vertical position, make sure the area is clear, and blow out cylinder valves before attaching regulators.

Figure 9

b. Release adjusting screw on regulators before opening cylinder valves.

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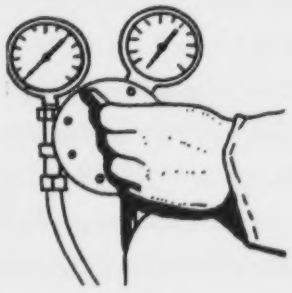
Figure 10

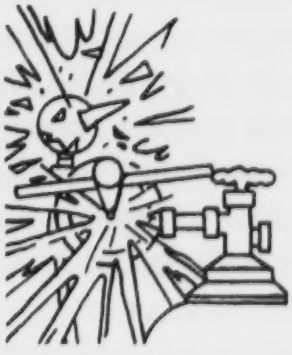


c. Stand on the side opposite the regulator when opening a cylinder valve.

Figure 11

d. Open cylinder valve SLOWLY.

Figure 12



e. Do not use or compress acetylene at pressures higher than 15 psi.

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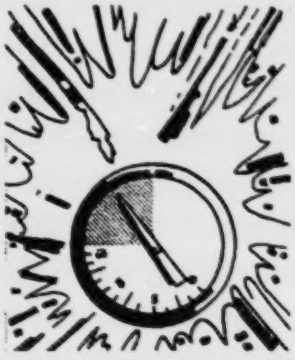
Figure 13



f. Purge oxygen and fuel gas lines before lighting torch.

Figure 14

g. Light acetylene before opening oxygen valve on torch.

Figure 15

h. NEVER use oil on regulators, torches, fittings, or other equipment in contact with oxygen.

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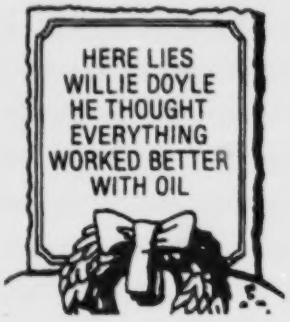
Figure 16



i. Do not use oxygen as a substitute for compressed air.

Figure 17

j. Keep heat, flames, and sparks away from combustibles.

Figure 18

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Objective 13

Types of oxyacetylene flames

Name	Characteristics	Uses
Oxidizing	Excess oxygen to acetylene burning ration with no acetylene feather, and makes a harsh, hissing sound	Least used because it oxidizes metal, but is used for braze welding with a bronze rod
Neutral X	Burns equal amounts of oxygen and acetylene, and has a clear, clean-edged inner cone	The most used flame for oxyacetylene applications
Reducing X to 2X (Lightly carburizing)	Burns slightly more acetylene than oxygen, acetylene feather appears just beyond the point of the neutral flame, and is also a carburizing flame	Used for backhand welding and for welding mild steel with low-alloy rods
Carburizing 2X to 3X	Excess acetylene to oxygen burning ration with an acetylene feather two to three times the length of the inner cone	Used for some hardfacing, but must be used selectively because it adds carbon to base metals

Objective 14

Guidelines for flame adjustment

a. To secure a neutral flame, always start with an excess of acetylene, then increase the flow of oxygen or decrease the flow of acetylene until the acetylene feather disappears from the center cone.

b. An excess of acetylene is easy to spot, but an excess of oxygen is difficult to spot except that it will cause molten metal to spark excessively.

c. Make sure regulator working pressures are those recommended for the tip size you are using.

d. Beginning welders should not use the harshest flame the welding torch can produce.

   Note: The harshest flame is one which would separate slightly from the tip of the torch if each gas pressure were increased slightly.

e. Cut back flame length slightly when a flame is too harsh.

   Note: Cutting back the flame will produce a softer flame, which is best for beginning welders because it makes welding a bit slower but affords better control.

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Objective 15

Causes and detection of backfire and flashback

a. Backfire is a momentary backing of the flame into the welding tip; it is usually accompanied by a loud pop.

> **Caution:** Repeated backfire indicates the potential for greater problems and the equipment should be shut down and serviced.

b. Overheating a tip, using a tip too close to the work, or touching the tip to the work can all cause backfire and flashback.

c. An insufficient volume of oxygen or acetylene or incorrect gas pressures can also cause backfire and flashback.

d. Dirty seating surfaces, leaks from loose tips, and failure to purge the equipment can also cause backfire and flashback.

e. Flashback is a continued burning back of the flame into the tip, mixer, or torch body and is easy to detect because it is accompanied by a loud hiss or squeal.

> **Caution:** When flashback occurs, IMMEDIATELY shut off the oxygen torch valve, then the acetylene torch valve, and then SHUT THE SYSTEM DOWN COMPLETELY and check for damage.

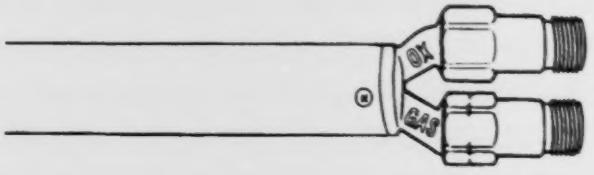
f. Operator, equipment, and even the workplace can be in danger with both backfire and flashback; remember the auditory alert sound for both, a loud POP for backfire and a loud HISS or SQUEAL for flashback — the sounds indicate immediate danger and the need for immediate shutdown.

Objective 16

Ways to control backfire and flashback

a. Backfire is a momentary backing of flame into a welding tip and is controlled with reverse flow check valves in both the oxygen and fuel gas intakes to the torch.

Figure 19



b. Flashback is a condition where a flame not only goes into the torch tip, but continues burning through the tip and torch body so that it endangers both hoses and the entire system.

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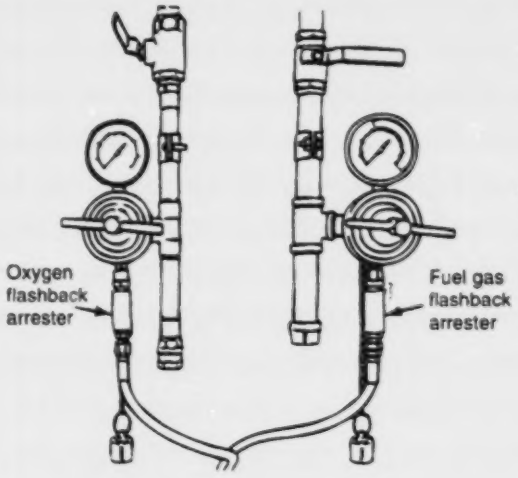
c. It is common arrangement to have reverse flow check valves at the entry points to the torch while flashback arresters are installed at the oxygen and fuel gas regulators on cylinders or at the regulators on manifold systems.

Figure 20



d. Both reverse flow check valves and flashback arresters should be inspected at regular intervals and replaced if there are evident signs of wear.

Objective 17

Welding tip selection

a. Welding tip sizes should be selected according to the thickness of the metal to be welded and type of fuel gas to be used.

b. Drill size listed with a tip indicates the size of the orifice when new so the correct size tip cleaner can be selected and the orifice can be properly checked for wear.

> **Caution:** When using a tip cleaner on an orifice, select a cleaning probe slightly smaller than the orifice, and work your way up to the proper size, but never force an oversize probe into an orifice. The small diameter probe is easy to break off in the orifice, and that renders the tip useless.

c. Tip manufacturer's recommended regulator pressures for fuel gases should not exceed the minimum or maximum recommended for a specific size tip.

d. Tip size and regulator pressures recommended by the manufacturer should be carefully followed.

Note: Tip data may change with different manufacturers.

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e. Gas consumption data on tip selection charts are for estimating purposes, and the actual consumption will vary with the material being welded and operator's skill.

f. Gas pressure recommendations on tip data charts are usually based on a hose length of 25 feet, and longer lengths of hose should have about 3 psi added per each additional 25 feet.

Figure 21

Metal Thickness	Tip Size	Drill Size	Oxygen Pressure PSIG		Acetylene Pressure PSIG		Acetylene Consumption SCFH*		
			Min.	Max.	Min.	Max.	Min.	Max.	
Up to 1/32"	000	75	3	5	3	5	3/4	1 1/2	Gas consumption data is merely for rough estimating purposes. It will vary greatly with the material being welded and the particular skill of the operator. Pressures are approximate for hose length up to 25 ft. increase for longer hose lengths about 3 psi per 25 feet.
1/64" – 3/64"	00	70	3	5	3	5	1 1/2	2 1/2	
1/32" – 5/64"	0	65	3	5	3	5	2 1/2	4	
3/64" – 3/32"	1	60	3	5	3	5	4	6	
1/16" – 1/8"	2	56	3	5	3	5	6	10	
1/8" – 3/16"	3	53	4	7	3	6	9	18	
3/16" – 1/4"	4	49	5	10	4	7	15	28	
1/4" – 1/2"	5	43	6	12	5	8	22	40	
1/2" –3/4"	6	36	7	14	6	9	30	52	
3/4" – 1 1/4"	7	30	8	16	7	10	38	66	
1 1/4" – 2"	8	29	10	19	8	12	48	82	
2" – 2 1/2"	9	28	12	22	9	14	58	100	
2 1/2" – 3"	10	27	14	24	10	14	70	118	
3" – 3 1/2"	11	26	16	26	11	15	84	138	
3 1/2" – 4"	12	25	18	28	12	15	100	160	

*Oxygen consumption is 1.1 times the acetylene under neutral flame conditions.

Objective 18

Filler rod selection, handling, and safety

a. Select a rod that has the same or similar properties of the base metal.

b. Select a rod that is the correct size for the thickness of the metal being welded.

Note: The general rule is that the rod should have a diameter equal to the metal being welded, but since standard rod diameters go to only 1/4", adjustments in weld design are required for certain applications.

c. Keep rods properly labeled and stored in a clean, dry place.

d. Keep hot filler rods away from combustible materials.

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e. Bend the end of the filler rod to prevent eye injuries.

Note: This is especially a good rule for beginners in a school shop, and sometimes instructors have students cut the filler rods in half to minimize problems.

Figure 22

Metal	Flame Adjustment	Flux	Welding Rod
Steel, cast	Neutral	No	Steel
Steel pipe	Neutral	No	Steel
Steel plate	Neutral	No	Steel
Steel sheet	Neutral	No	Steel
	Slightly oxidizing	Yes	Bronze
High carbon steel	Reducing	No	Steel
Wrought iron	Neutral	No	Steel
Galvanized iron	Neutral	No	Steel
	Slightly oxidizing	Yes	Bronze
Cast iron, gray	Neutral	Yes	Cast iron
	Slightly oxidizing	Yes	Bronze
Cast iron, malleable	Slightly oxidizing	Yes	Bronze
Cast iron pipe, gray	Neutral	Yes	Cast iron
	Slightly oxidizing	Yes	Bronze
Cast iron pipe	Neutral	Yes	Cast iron or base metal composition
Chromium-nickel steel castings	Neutral	Yes	Base metal composition or 15-12 chromium-nickel steel
Chromium-nickel steel (18-8 and 25-12)	Neutral	Yes	Columbium stainless steel or base metal composition
Chromium steel	Neutral	Yes	Columbium stainless steel or base metal composition
Chromium iron	Neutral	Yes	Columbium stainless steel or base metal composition

Objective 19 **AWS designations for iron and steel gas welding rods**

a. Rods are identified with a two-letter, two-digit designation such as RG65.

b. The "R" indicates a rod, the "G" indicates the rod is to be used with gas welding, and the "65" indicates the approximate tensile strength in thousands of pounds per square inch or a 65,000 pounds per square inch tensile strength.

Objective 20 **Flux selection, handling, and safety**

a. Flux selection will always depend on the type of metal being welded, weld design, and specifications.

b. Flux should normally be used for welding cast iron, for braze welding stainless steel and cast iron, for welding copper, aluminum, magnesium, and their alloys.

c. After use, the lid on a tin of flux should be securely resealed before storing.

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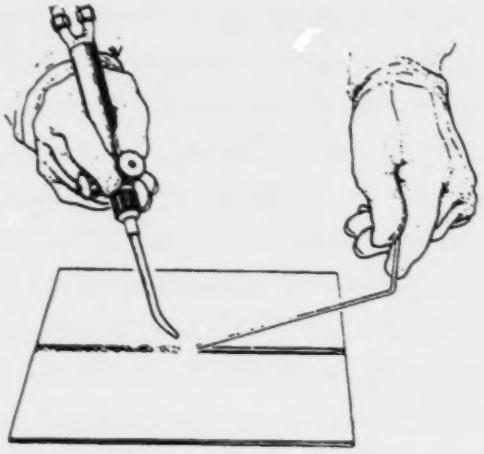
Objective 21

Welding positions

a. Position 1 or flat is an AWS designation which indicates that the surfaces of a workpiece lie parallel to the ground.

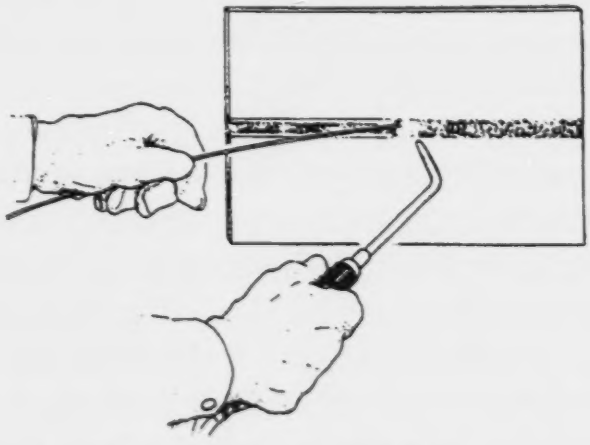
Figure 23



Courtesy Union Carbide Corporation, Linde Division.

b. Position 2 or horizontal is an AWS designation which indicates that the surfaces of a workpiece are parallel to the ground, but welding is performed below the work instead of above it.

Figure 24



Courtesy Union Carbide Corporation, Linde Division.

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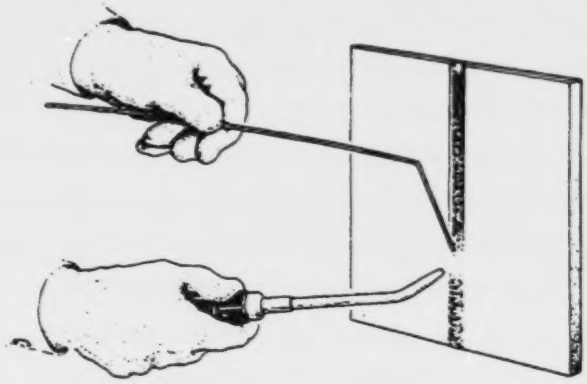
c. Position 3 or vertical is an AWS designation which indicates both surfaces of a workpiece and the line of the weld are perpendicular to the ground.

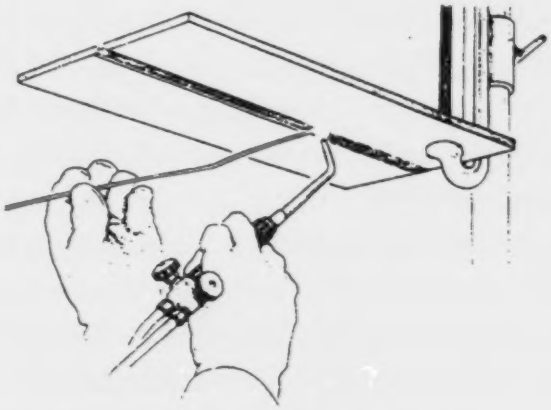
Figure 25



Courtesy Union Carbide Corporation, Linde Division.

d. Position 4 or overhead is an AWS designation which indicates that the surfaces of the workpiece are parallel to the ground, but welding is performed from below the workpieces instead of above it.

Figure 26



Courtesy Union Carbide Corporation, Linde Division.

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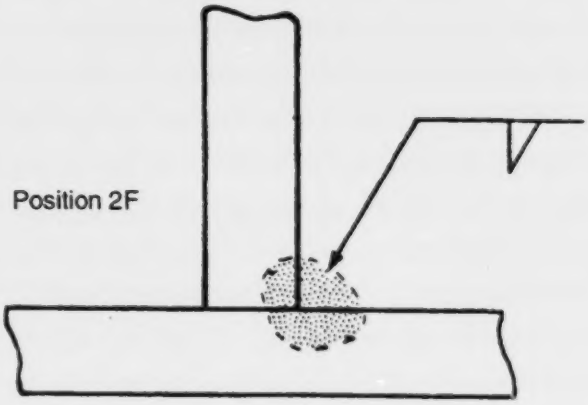
Information Sheet

Objective 22

Basic types of welds and their AWS symbols

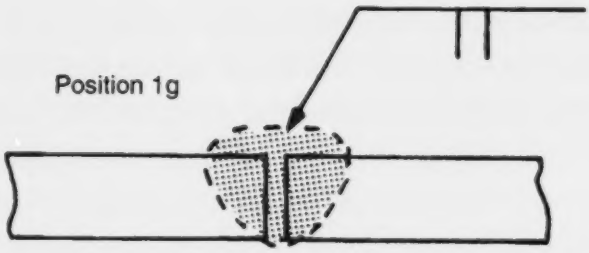
a. A fillet weld has the AWS designation of "F"; the fillet is a triangular-shaped weld that joins lap joints, T-joints, and corner joints.

Figure 27



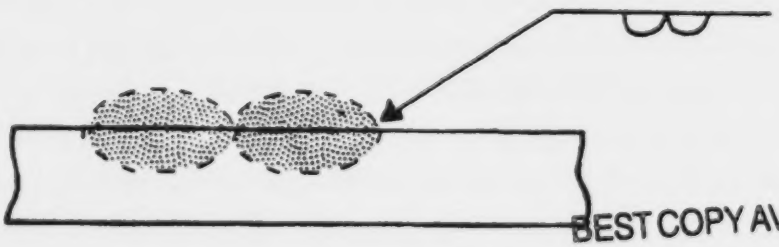
b. A groove weld has the AWS designation "G"; the groove weld is made in the groove between two pieces of metal.

Figure 28



c. Beads are surfacing welds made on the surface of the base metal to add to or build up the material for hard facing and other applications.

Figure 29



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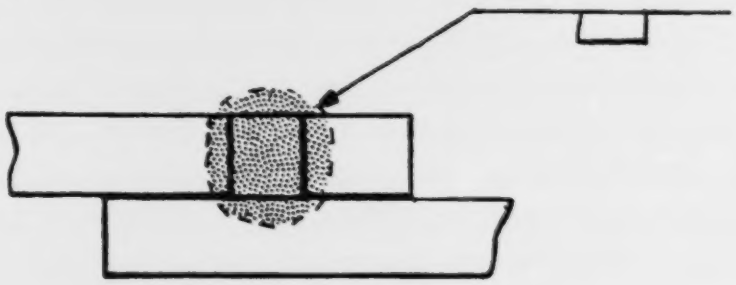
d. A plug or slot weld is a weld used to join metals by welding one member to another through a hole or slot.

Figure 30

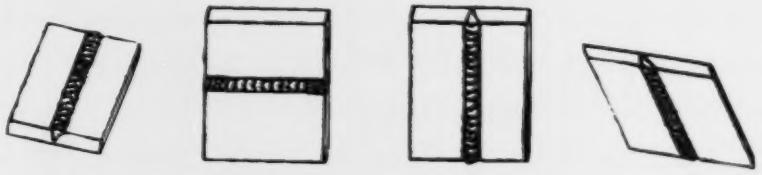


Objective 23

Basic welding joints and positions

a. **Butt joint**—A joint between the edges of two pieces of material lying in the same plane

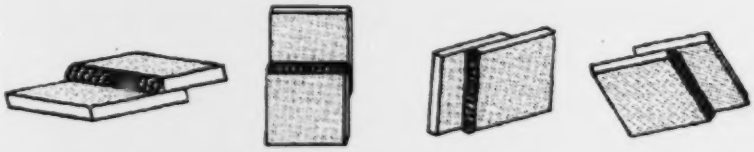
Figure 31



1G 2G 3G 4G

b. **Lap joint**—A joint made by overlapping one piece of material over another

Figure 32



1F 2F 3F 4F

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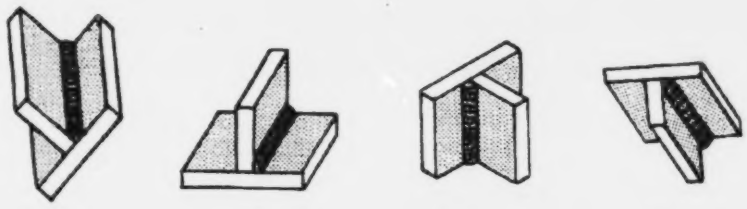
c. **T-joint**—A joint between two pieces of material positioned at 90° right angles to each other in the form of the letter "T"

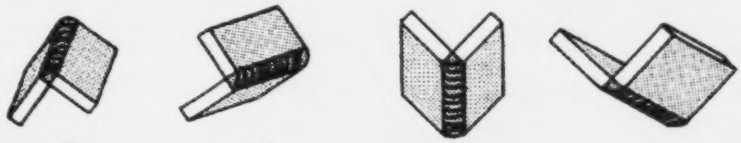
Figure 33



1F 2F 3F 4F

d. **Corner joint**—A joint between two pieces of material positioned at 90° right angles to each other to form the letter "L"

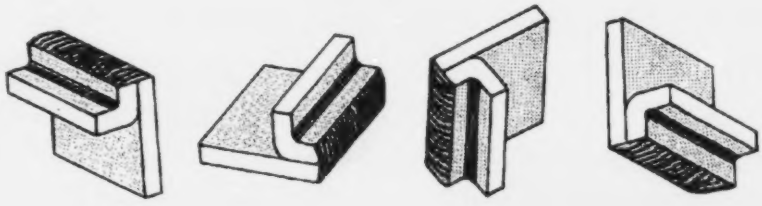
Figure 34



1F 2F 3F 4F

e. **Edge joint**—A joint between the edges of parallel plates with the end of one plate bent to form a 90° right angle above the surface of the other plate

Figure 35



1G 2G 3G 4G

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Objective 24

Elements of good fusion welding

a. **Flame and rod angles**—The relative angles of the rod and the flame in relationship to the work affect welding speed and weld quality.

b. **Flame-to-work distance**—Normally, the tip of the flame's center cone should be kept about 1/8" from the surface of the work or the weld puddle.

Note: With skill, welders learn to vary work distance to dig into the puddle or to back off for slower welding in difficult positions or by varying torch angle.

c. **Bend in rod**—Putting a bend in the rod about 8" from the end keeps your rod hand out of the path of hot air downstream from the flame, provides better vision of the weld area, and gives better control.

Note: To bend a rod, heat it at 8" from the end and force it against the work table or the work itself.

d. **Rod freeze**—When the rod sticks to the weld, don't try to pull it loose, but melt it loose with the flame.

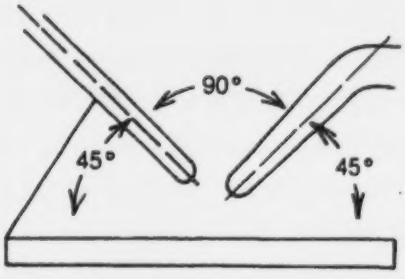
e. **Stub ends**—Eliminate the waste of stub ends by saving and welding stub ends together or by welding another rod onto the stub end.

Objective 25

Rules of thumb for rod and torch angles

a. The best practice for beginners is to hold both the rod and the torch at 45° angles from the surface of the workpiece to create a 90° angle between the two.

Figure 36



b. When the torch is held at a 45° angle, it not only reduces heat input directly under the tip, but spreads heat ahead of the weld for better control.

c. The flame should always be pointed along the line of the weld and not angled off to one side.

d. The more vertical the angle of the torch flame, the more heat input under the torch tip.

e. With experience, more vertical torch angles are helpful in certain situations, but used improperly, a more vertical torch angle usually results in burning a hole through the base metal.

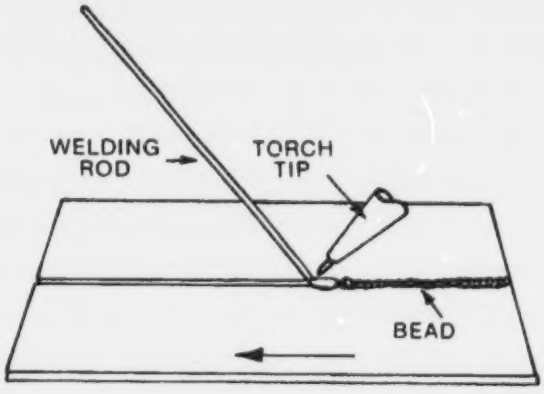
Objective 26

Guidelines for using the forehand technique in fusion welding

a. For a right-handed operator, welding proceeds from right to left, but welding proceeds from left to right for a left-handed operator.

b. The torch flame is pointed toward the unfinished end of the weld, and the filler rod is pointed toward the finished end of the weld.

Figure 37



Objective 27

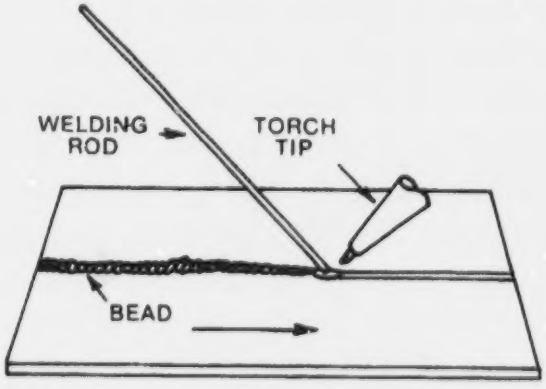
Guidelines for using the backhand technique in fusion welding

a. For a right-handed operator, welding proceeds from left to right, but welding proceeds from right to left for a left-handed operator.

b. The torch flame is pointed toward the finished end of the weld, and the filler rod is pointed toward the unfinished end of the weld.

c. The backhand technique is good in some circumstances, but beginners should stick to the forehand technique until they develop skill.

Figure 38



Objective 28

Techniques for controlling flame and rod motions

a. Keep both the flame and the filler rod in almost constant motion with the flame moving slowly forward across the line of the weld in a back and forth motion as the rod moves in and out of the leading edge of the puddle.

b. Keep the motion of the rod opposite the motion of the flame so that the inner cone of the flame is pointed directly at the rod for only a part of each back and forth cycle.

c. When the end of the rod is drawn away from the puddle, don't draw it away very far, but keep it in the outer cone of the flame.

d. Remember that puddle control can also come from the heat of the flame and rod motion because the flame adds heat while the rod takes away heat, so control can be a product of these elements too.

Objective 29

Guidelines for preheating, interpass, and postheating

a. With the exception of cast iron, preheating, interpass, and postheating in oxyacetylene welding are usually accomplished in the welding process.

b. Additional preheating and postheating are usually required with cast iron.

c. An oxyacetylene flame is also used for preheating, interpass, and postheating in other welding processes.

Objective 30

Procedures for cleanup, inspection, and testing

a. **Cleanup**—After all welds, from first to last, the weld area should be cleaned with a wire brush until the entire weld is completely visible.

b. **Inspection**—After cleaning, the weld should be visually inspected to judge if it is acceptable or if its appearance indicates the need for testing.

Note: A visual inspection after each pass should be considered part of any welding procedure, and every welder should develop the habit of inspecting his or her welds to the point that it becomes an automatic reflex.

c. **Testing**

- A nondestructive test is a test that checks the quality and soundness of a weld without destroying the base metal and the weld itself.
- A visual test, x-ray test, magnetic particle test, and ultrasonic test are all nondestructive tests.
- A destructive test is a test that checks the quality and soundness of a weld by destroying the weld itself or the weld and the base metal.
- A guided bend test, acid etching test, and nick-break test are all destructive tests.

Note: Beginning welders should become familiar with testing procedures and your instructor will determine the type or types of testing you should use.

Information Sheet

Objective 31

Steps in setting up cylinders and regulators

a. Secure cylinders with a chain to a cylinder cart or wall support.

b. Remove cylinder valve caps.

c. Examine cylinder valve threads for damage and wipe clean of any dust, oil, or grease with a clean, dry cloth.

d. Stand to one side of the oxygen cylinder valve, open it momentarily and then close it quickly to purge the valve, then repeat the process for the fuel gas cylinder.

> **Caution:** When purging valves or fuel lines, work area must be well ventilated.

e. Attach oxygen regulator to oxygen cylinder valve and tighten with only a cylinder wrench.

f. Attach fuel gas regulator to fuel gas cylinder valve and tighten only with a cylinder wrench.

g. Release pressure on both regulators by turning each regulator adjusting screw counterclockwise until tension is completely released on the adjusting screw.

Objective 32

Steps in purging oxygen and fuel gas regulators

a. Stand to one side and open oxygen cylinder valve SLOWLY until inlet pressure gauge needle moves slowly to maximum reading, then open cylinder valve fully.

b. Purge oxygen regulator by turning the adjusting screw clockwise momentarily, then counterclockwise to release pressure.

c. Stand to one side and open fuel gas cylinder valve, and if it is an acetylene cylinder, open only one-half to three-quarters of a turn.

> **Caution:** When a key wrench is used to open an acetylene cylinder, it should be left in place during all operations to permit rapid shutdown in case of emergency.

d. Purge fuel gas regulator by turning the adjusting screw clockwise to open it momentarily, then turn adjusting screw counterclockwise to release pressure.

Objective 33

Final steps in setting up oxyfuel equipment

a. Attach check valves to regulators.

b. Attach hoses to check valves and tighten both with an open end wrench.

Note: Check valves can be installed between the torch body and the hoses.

c. Purge both hoses by turning each regulator adjusting screw clockwise for 3 to 5 seconds, then counterclockwise to release pressure.

d. Attach hoses to torch body and tighten with an open end wrench.

e. Attach proper size welding tip to the torch body, and tighten the tip finger tight.

f. Turn torch needle valves clockwise to close them.

g. Set 5 to 10 psi on each regulator by turning the individual adjusting screws clockwise until needle on working pressure gauge reads the desired pressure.

Caution: Never exceed 15 psi on acetylene.

h. Brush leak test solution on all threaded connections to check for leaks, and if bubbles form, retighten connections with a wrench and check them again.

Note: Leak testing is best accomplished with leak detector solution because some soap contains oil.

i. Purge torch by opening fuel gas valve half a turn for 2 seconds, then closing, and repeating the procedure for oxygen.

Unit Contents

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* Job Sheets

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2—Set Up, Adjust Cutting Flame for Star Pattern and Shut Down Oxyfuel Cutting Equipment 35
3—Make 90° Cuts and Restart a Cut on Mild Steel 39
4—Make a Flame-Beveled Cut on Mild Steel Plate 43
5—Cut Holes in Mild Steel 45
6—Lay Out a Pattern on Mild Steel Plate and Cut the Pattern to Specifications 49
7—Set Up and Cut a 30° Bevel With a Track-Type Torch 51
8—Cut a Pipe Bevel By Hand 53
9—Set Up and Bevel a Pipe With a Pipe Beveling Machine 57

* Job Sheets are located in the Student Workbook

Prerequisites:
None

Learning Activities Sheet

Student Name _____

Place a checkmark in the appropriate box as you complete each of the steps below.

❑	1. **Take**	Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.
❑	2. **Read**	Objective Sheet.
❑	3. **Study**	Information Sheet, Objectives 1 through 28.
❑	4. **View**	Videotape detailing Oxyacetylene and Oxyfuel Cutting Safety.
❑	5. **Observe**	Demonstration of procedures to be used in completing Job Sheet 1.
❑	6. **Do**	Job Sheet 1, "Set Up, Adjust Cutting Flame, and Shut Down Oxyacetylene Cutting Equipment."
❑	7. **Stop**	Have instructor evaluate your performance and if evaluation is satisfactory, continue to step 8. If the evaluation is not satisfactory, study the procedure in Job Sheet 1 and do it again.
❑	8. **Do**	Job Sheet 2, "Set Up, Adjust Cutting Flame for Star Pattern and Shut Down Oxyfuel Cutting Equipment", Job Sheet 3, "Make 90° Cuts and Restart a Cut on Mild Steel ", Job Sheet 4, "Make a Flame-Beveled Cut on Mild Steel Plate", Job Sheet 5, "Cut Holes in Mild Steel", Job Sheet 6, "Lay Out a Pattern on Mild Steel Plate and Cut the Pattern to Specifications", Job Sheet 7, "Set Up And cut a 30° Bevel with a Track-Type Torch", Job Sheet 8, "Cut a Pipe Bevel by Hand", and Job Sheet 9, "Set Up and Bevel a Pipe with a Pipe Beveling Machine."
❑	9. **Stop**	After completing each job sheet, have your instructor evaluate your performance. If the evaluation is satisfactory, continue to the next job sheet. If the performance is not satisfactory, study the procedure in that job sheet, and redo the job sheet. After satisfactorily completing all the job sheets, continue to step 10.

❑ 10.	**Check**	With instructor for any additional assignments to be completed.
❑ 11.	**Do**	Additional assignments listed below.
❑ 12.	**Take**	Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.
❑ 13.	**Stop**	Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

_____

_____

***Permission to duplicate this form is granted.**

Objective Sheet

Unit Objective

After completing this unit, the student should be able to set up, adjust, and shut down oxyacetylene and oxyfuel cutting equipment, cut and bevel mild steel plate, cut holes and patterns in mild steel plate, bevel a pipe manually and with a pipe cutting machine and cut a bevel with a track-type torch. The student will demonstrate these competencies by completing the job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to oxyacetylene and oxyfuel cutting with their definitions.
2. Complete statements about advantages of oxyacetylene and oxyfuel cutting.
3. Select true statements about alternate fuels.
4. Complete statements about alternate fuel gas data.
5. Select true statements about equipment requirements for alternate fuels.
6. Solve problems about liquid oxygen applications and safety.
7. Identify parts of an equal-pressure cutting torch.
8. Identify parts of an injector cutting torch.
9. Select true statements about cutting tip design.
10. Complete statements about high-volume heating tip design.
11. Select guidelines for acetylene cutting tip selection.
12. Select true statements about guidelines for cleaning acetylene cutting tips.
13. Match acetylene tip cleaning tools with their uses.
14. Select true statements about rules for tip use.
15. Select true statements about metal preparation for oxyfuel cutting.
16. Arrange in order the steps in properly starting a cut.
17. Complete statements about techniques for restarting a cut.
18. Select true statements about techniques for cutting straight lines.

Objective Sheet

19. Select techniques for controlling kerf and drag.

20. Complete statements about elements of a good cut.

21. Select causes for characteristics of poor cuts.

22. Complete statements about safety requirements for oxyacetylene and oxyfuel cutting.

23. Select true statements about characteristics of manifold systems.

24. Select true statements about characteristics of track-type cutting machines.

25. Select true statements about characteristics of shape cutting machines.

26. Select true statements about characteristics of automated cutting machines.

27. Select true statements about characteristics of pipe beveling machines.

28. Complete statements about eye protection required for oxyacetylene and oxyfuel cutting.

*29. Set up, adjust cutting flame, and shut down oxyacetylene cutting equipment. (Job Sheet 1)

*30. Set up, adjust cutting flame for star pattern, and shut down oxyfuel cutting equipment.(Job Sheet 2)

*31. Make 90° cuts and restart a cut on mild steel. (Job Sheet 3)

*32. Make a flame-beveled cut on mild steel plate. (Job Sheet 4)

*33. Cut holes in mild steel. (Job Sheet 5)

*34. Lay out a pattern on mild steel plate and cut the pattern to specifications. (Job Sheet 6)

*35. Set up and cut a 30° bevel with a track-type torch. (Job Sheet 7)

*36. Cut a pipe bevel by hand. (Job Sheet 8)

*37. Set up and bevel a pipe with a pipe beveling machine. (Job Sheet 9)

* Job Sheets are located in the Student Workbook.

Information Sheet

Objective 1

Terms and definitions

a. **Drag line**—A condition where the most distant portion of the cutting stream lags behind the stream nearest the cutting tip

b. **Kerf**—The width of the cut produced during a cutting process

c. **Slag**—A nonmetallic residue left after oxyacetylene cutting

d. **Soapstone**—A talc-based marking pencil that has a soapy feel and is used for marking lines on workpieces

e. **Wraparound**—A pliable strip of durable gasket material with edges that are perfectly straight and parallel so that it provides a guide for marking a straight line around the circumference of a pipe

Objective 2

Advantages of oxyacetylene and oxyfuel cutting

a. Both oxyacetylene and oxyfuel cutting are not dependent on electrical power and are readily portable.

b. Both oxyacetylene and oxyfuel cutting equipment are relatively inexpensive when compared to other cutting procedures like plasma arc cutting.

c. When properly executed, oxyacetylene cutting can deliver a high-quality cut on low carbon steel plate up to 3/16″ thick, but cuts on thicker plate may require an alternate fuel application.

d. Oxyacetylene cutting is usually done manually, but it is readily adaptable to automatic processes.

Objective 3

Alternate fuels

a. Alternate fuels for oxyfuel applications include Mapp®, Propylene, Propane, Natural Gasm and others.

b. Alternate fuels are popular because of their:

- Economy
- Convenience
- Performance
- Safety

c. Alternate fuels are economical because they offer more BTUs per dollar, less cylinder handling cost, less cylinder rental, and equipment lasts longer.

d. Alternate fuels are convenient because they offer more product per cylinder, less weight per cylinder, and less maintenance per cylinder.

e. Alternate fuels perform better on many applications because of more BTUs per cubic foot, less chipping and grinding, less top edge rollover, less hardening of face cut, and broad preheat adjustment range.

f. Alternate fuels are safer because they resist flashback and backfire, they can be used at higher pressures, less UV protection is required, and they produce less soot to pollute the workplace.

> Caution: Propane and propylene are heavier than air and should be used with caution in enclosed or below grade areas; in fact, all oxyfuel combinations have the potential to be explosive so always handle them with care.

Objective 4 **Alternate fuel gas data**

a. As a rule of thumb, and with the proper gas apparatus, one large cylinder of alternate fuel will do the same amount of work as approximately five large cylinders of acetylene.

b. Acetylene continues to be the preferred gas for cutting thin plate of 3/16" or less, for piercing, for beveling, for flame hardening, and for gas welding.

c. Alternate slower-burning fuel gases are often selected for cutting heavy plate of 1" or more, for a broad range of heating applications, for plate clean-up, and for precise preheat oxygen control.

d. The following chart shows several categories of performance comparisons between acetylene and alternate fuels.

Fuel Gas Technical Data

	Acetylene	Mapp®	Proylene	Propane	Natural Gas
Max. Flame Temp. F°	5720	5340	5240	5130	5040
Oxygen to Fuel Ratio (max. temp)	1.5:1	3.5:1	3.6:1	4.5:1	1.9:1
Neutral Flame Temp F°	5620	5270	5190	5090	5010
Oxygen to Fuel Ratio (neutral)	1.1:1	2.5:1	2.6:1	3.7:1	1.5:1
BTU's per Cubic Foot	1470	2400	2370	2563	1000
Burning Velocity in O_2	22.7/sec.	15.4/sec.	15.0/sec.	12.2/sec.	15.2/sec.
Flammability Limits in O_2	3-93%	2.5-60%	2.5-60%	2.4-57%	5-59%
Flammability Limits in Air	2.5-80%	3.4-10.8%	2.0-11.1%	2.3-9.5%	5.3-14%
Specific Gravity (air=1@60°F)	0.91	1.48	1.45	1.56	.55
Vapor Pressure (PSIG@70°F)	250	94	135	120	(line pressure)
Lbs./Gal. Liquid	–	4.8	4.35	4.28	–
Cu.Ft./Lb. Gas	14.6	8.85	9.0	8.66	23.6
Cu. Ft./Gal. Liquid	–	43.5	43	37	–

Courtesy Harris Calorific, Inc.

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Objective 5

Equipment requirements for alternate fuels

a. Using an alternate fuel with equipment designed for acetylene will not provide all the benefits an alternate fuel can offer.

b. Merely changing from an acetylene to an alternate fuel tip does not offer all the benefits of an alternate gas, the alternate fuel gas will perform better with an equipment conversion to an injector mixer.

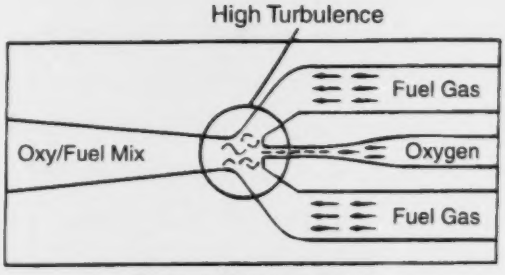
c. Injector mixers designed for alternate fuels mix the oxygen and fuel gas thoroughly for increased BTU output and maximum flame temperature.

d. Injector mixers, as opposed to equal pressure mixers, provide exceptional flame stability and a minor fluctuation in gas pressure does not adversely affect flame stability and torch performance.

e. Injector mixers are easier to adjust and operate, and adjusting the oxygen valve provides more or less preheat because the injector automatically maintains the optimum oxy/fuel ratio.

f. If necessary, injector mixers can operate efficiently on fuel gas pressures less than 2 PSIG.

Figure 1



Typical "F" Mixer Design

Courtesy Harris Calorific, Inc.

Objective 6

Liquid oxygen applications and safety

a. In facilities where cutting oxygen is used in volume, pressurized oxygen cylinders would have to be changed out so frequently that their use becomes impractical, so liquid oxygen cylinders are preferred for high-use applications.

b. Scrap yards where steel cutting is a primary activity use liquid oxygen almost exclusively as do facilities with machine cutting tables where pattern work and similar applications sometimes goes on 24 hours a day.

c. A standard, pressurized oxygen cylinder holds a volume of about 260 cubic feet while a liquid oxygen cylinder holds 4800 cubic feet; divide 4800 by 260 to do the arithmetic and the ratio is about 18 to 1, in other words, it would take about 18 pressurized oxygen cylinders to equal the volume in one liquid oxygen cylinder.

d. A standard oxygen cylinder is pressurized at about 2,500 psi while a liquid oxygen cylinder is pressurized at about 350 psi, so this means that liquid oxygen cylinders use a low-pressure, high-flow regulator, but other than that working with liquid oxygen cylinders is like working with standard pressurized cylinders.

e. Because of the lower operating pressure, liquid oxygen cylinders are probably safer to work with than the high-pressure standard oxygen cylinders, but there are special safety matters and an operator should always read the MSDS, Material Safety Data Sheet, that should be posted in any facility where liquid oxygen is being used.

f. Never work around liquid oxygen with oil hands or oily clothes.

g. Never roll a cylinder of liquid oxygen across a floor; if the cylinder must be moved, Use a cart to transport it in an upright position.

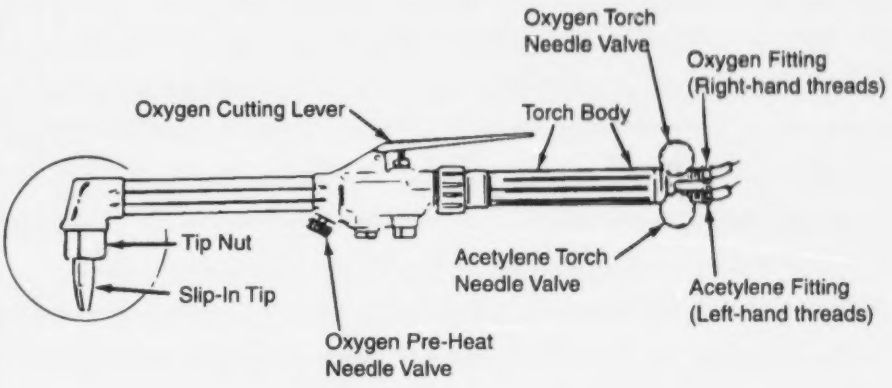
h. When regulator pressure on a liquid oxygen cylinder reaches 50 pounds, change to a new cylinder.

i. General safety rules apply to working with liquid oxygen and that means a a workplace free of clutter and debris, good ventilation, and a fire extinguisher handy for emergencies.

Objective 7

Parts of an equal-pressure (two-part) cutting torch

Figure 2



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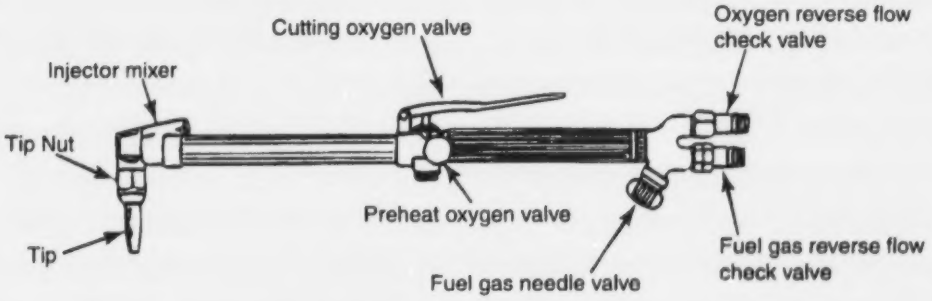
Objective 8

Parts of an injector (one-part) cutting torch

Figure 3



Objective 9

Cutting tip design

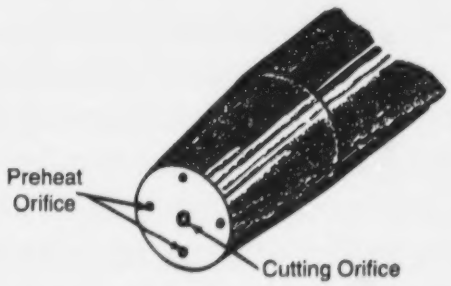
a. Cutting tips can be quickly changed so cutting can quickly be adapted to different thicknesses of metal.

b. Cutting tips are designed with two or more preheat orifices and one oxygen orifice.

c. Preheat orifices provide a mixture of oxygen and acetylene for preheating a base metal.

d. The single oxygen orifice directs a pressurized stream of pure oxygen onto the heated metal to accelerate the oxidation process that blows the metal away and completes the cut.

Figure 4



e. Oxyacetylene cutting tips have to be tightened with a wrench.

Objective 10

High-volume heating tip designs

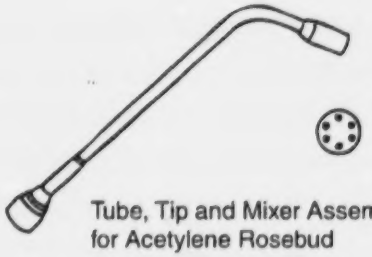
a. Tips designed to direct high volume gas flow for heating a confined area are classified as heavy duty heating tips or nozzles and are often referred to as "rosebuds."

b. Since these heavy-duty, high-volume tips are designed strictly for heating, they do not have a center orifice like cutting tips do.

c. Rosebuds for high-volume acetylene heating have no center orifice and the heating orifices are round and in a circular ring.

d. Acetylene rosebuds are frequently used with extension tubes to obtain better heat concentration.

Figure 5



Tube, Tip and Mixer Assembly
for Acetylene Rosebud

e. Rosebuds for high-volume fuel gas heating have no center orifice and the heating orifices are slotted and in circular rings.

Figure 6

Rosebud for Fuel Gas

f. Another readily observable feature of a fuel-gas rosebud is the raised circular ring around the tip face; this design permits the rosebud to cradle the flame and concentrate the heat, another economy factor of fuel gases.

Note: Rosebuds for MAPP® gas do not have the raised ring.

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Objective 11

Guidelines for oxyacetylene cutting tip selection

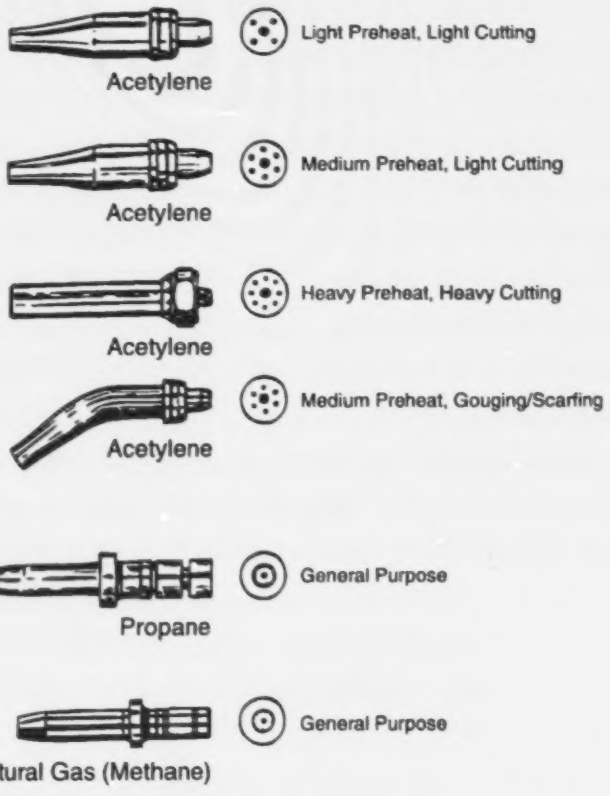
a. Determine the thickness of material to be cut and use the size tip recommended by the manufacturer.

b. Tip size has a direct relation to gas regulator pressures and pressures recommended by the manufacturer should always be followed.

c. Tip size affects rate of cutting speed and should be based on the needs of the cutting application.

d. Tip orifice should be compatible with the nature of work and fuel gas used.

Figure 7—Typical Cutting Tips and Orifices



Information Sheet

Objective 12

Guidelines for cleaning oxyacetylene cutting tips

a. Because cutting tips inevitably pick up carbon and/or slag, clean cutting tips often.

b. Always select a cleaning probe smaller than the orifice to be cleaned; never force a cleaning probe into an orifice.

c. Take special care not to break the cleaning probe off inside the orifice.

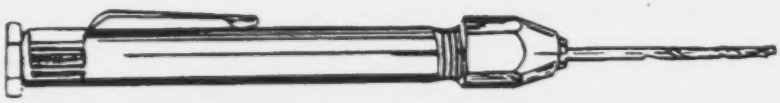
d. Be careful with the seating edges on cutting tips because some of them can be easily damaged.

Objective 13

Oxyacetylene tip cleaning tools and their uses

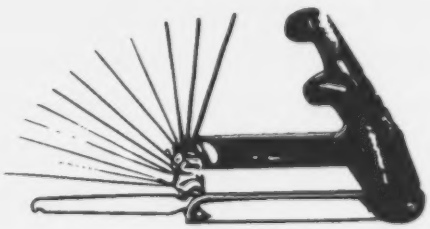
a. **Tip drill**—A miniature drill; used for cleaning and reconditioning orifices

Figure 8



b. **Tip cleaner**—A device with a series of small file-like probes that are gauged to match specific orifice openings; used to remove carbon build-up inside the tip

Figure 9



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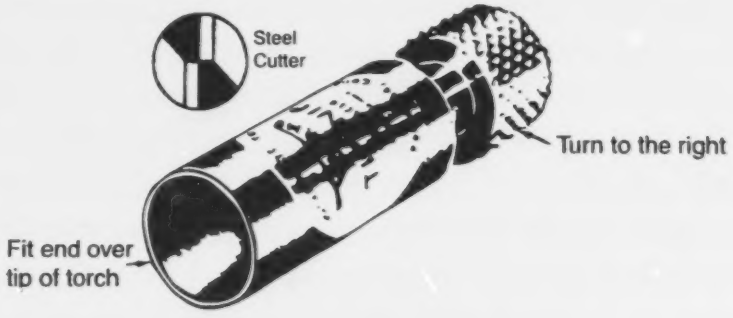
c. Tip nip—A circular-shaped device with small steel cutting blades inset so it can be placed over the entire end of the tip; used to both clean and restore the face of the tip

Figure 10



Objective 14

Rules for tip use

a. Never use a tip as a hammer to chip slag off a cut.

b. Never try to clean a tip by rubbing it on fire brick or against anything not designed for tip cleaning.

c. Never use an oily or greasy wrench to tighten a cutting tip; and never use an oily rag to clean dirt from a tip

Objective 15

Guidelines for metal preparation for oxyfuel cutting

a. For all critical cutting that requires following layout lines, burn metal free of oil and grease.

b. Remove scale and rust with a wire brush.

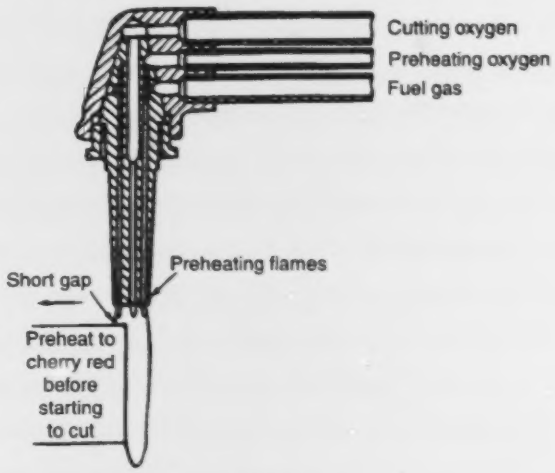
Information Sheet

Objective 16

Steps for properly starting a cut

a. Place the cutting tip so that the preheat flame is half on the metal and half off the edge of the metal, and the tip is perpendicular to the metal surface.

Figure 11



Courtesy American Welding Society

b. Place the tips of the preheat inner cones as close as possible to the metal without touching it.

c. Preheat the starting point until the metal is cherry red, then depress the oxygen cutting lever.

d. When cutting starts, tilt the cutting tip slightly in the direction of the cut and move the tip at a constant speed along the cut line.

Note: Torch angle will vary with the thickness of the metal being cut.

Objective 17

Techniques for restarting a cut

a. Anytime cutting stops, release the oxygen cutting lever immediately, preheat the restarting point at the edge only, and start again as if beginning a cut.

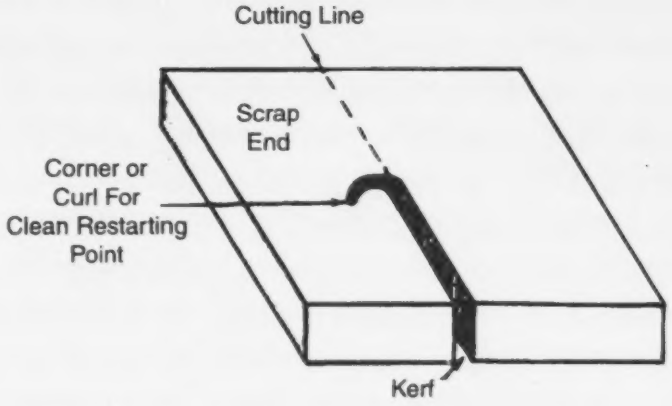
b. Blowholes are the biggest problem with restarting a cut, and blowholes can be avoided if you:

- Stop torch travel before releasing the oxygen cutting lever.

Note: This is especially effective on long cuts that you know will have one or more restarting points.

- Move the torch into the scrap area beyond the cutting line to form a corner or a curl about 1/4" long so the cut can be restarted in the scrap area and moved cleanly back to the original cutting line.

Figure 12



Note: This technique permits you to reposition the torch at comfortable intervals on long cuts, and when properly executed, the re-entry point along the cut line can hardly be detected.

c. Avoid cutting across slag when restarting because the slag will fly in all directions and create a hazard.

Objective 18

Techniques for cutting straight lines

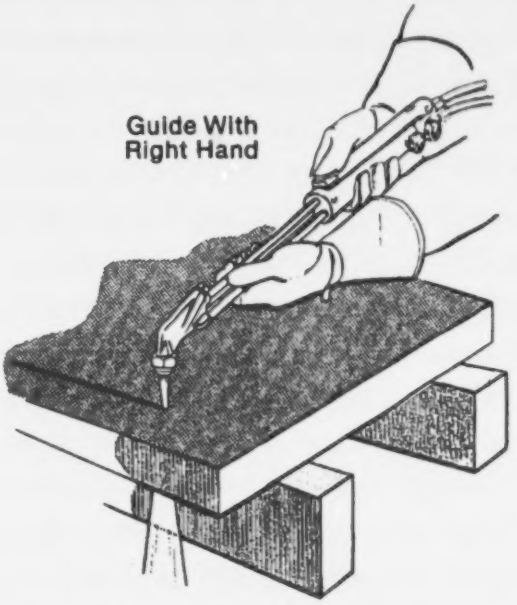
a. Hold the torch in your right hand with your thumb on the cutting lever and the torch centered in front of your body.

b. Support the torch in your left hand with a relaxed grip that will permit the torch to be turned.

c. As you move the torch along the cutting line, roll your left hand slightly to the left from time to time to make the adjustment required to keep the cutting flame straight along the line.

Note: The slight rolling technique with the left hand is the secret to good, straight cuts, so make some dry runs until you get the feel of it.

Figure 13



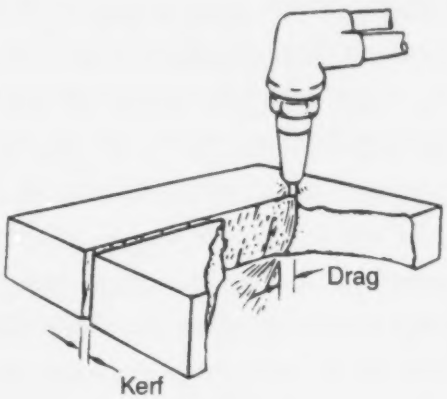
Courtesy Modern Engineering Company, Inc.

Objective 19

Techniques for controlling kerf and drag

a. Good oxyacetylene and oxyfuel cutting should produce a clean kerf with minimum drag, and this requires proper tip selection, proper travel speed, and proper fuel gas pressures.

Figure 14



Courtesy American Welding Society

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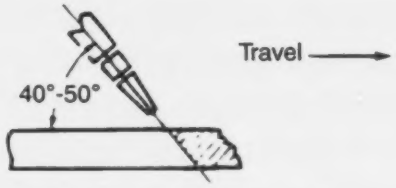
b. The thickness of the metal being cut should dictate tip selection and fuel gas pressures, but cutting torch angle is also important for a clean cut.

- For plate thickness 1/4″ and less, the torch should be angled about 40°-50° from the base metal surface.

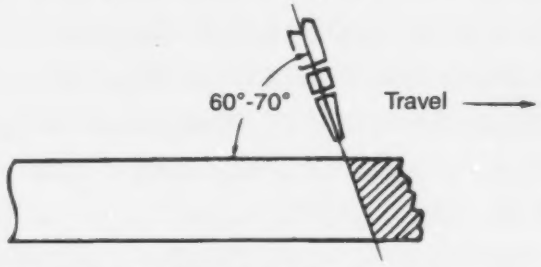
Figure 15



Courtesy American Welding Society

- For plate thickness 1/4″-1/2″, the torch should be angled about 60°-70° from the base metal surface.

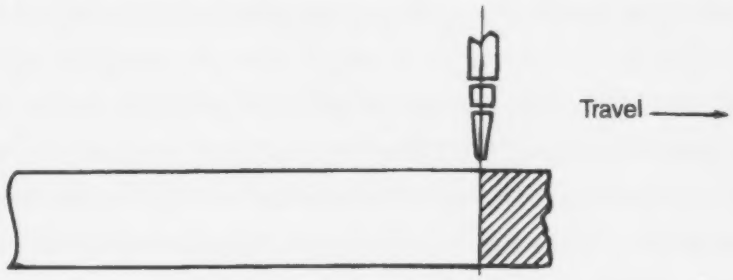
Figure 16



Courtesy American Welding Society

- For plate thickness over 1/2″, the torch should be held perpendicular to the plate.

Figure 17



Courtesy American Welding Society

Objective 20

Elements of a good cut

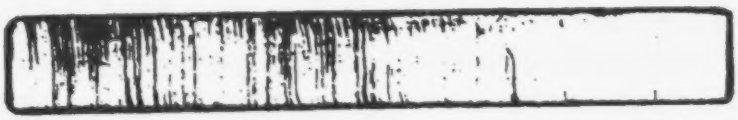
a. The edge is square.

b. Drag lines are vertical and clean.

c. There is no adhering slag at the bottom edge of the cut.

Note: The following illustration shows a proper cut made in a steel plate approximately 1″ thick and should be referenced for comparison with the cuts shown in objective 21.

Figure 18



Objective 21

Characteristics of poor cuts and their causes

a. **Bad gouging at bottom of cut**—Preheat flame was not hot enough, resulting in too slow a cutting speed.

Figure 19

b. **Top surface melted over, irregular cut edge, and excessive adhering slag**—Preheat flame was too strong.

Figure 20

c. **Top edge melted over**—Oxygen pressure too low, resulting in too slow cutting speed.

Figure 21

BEST COPY AVAILABLE

d. **Loss of cut control by operator**—Oxygen pressure was too high and the tip size was too small.

Figure 22

e. **Drag line irregularities**—Cutting speed was too slow.

Figure 23

f. **Pronounced break in the drag line with irregular cut edge**—Cutting speed was too fast.

Figure 24

g. **Cut edge wavy and irregular**—Torch travel was unsteady.

Figure 25

h. **Bad gouges at restarting point**—Cut was lost and improperly restarted.

Figure 26

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Information Sheet

Objective 22

Safety requirements for oxyacetylene and oxyfuel cutting

a. When oxyacetylene cutting, follow all the rules that apply to safe oxyacetylene welding.

b. Because higher oxygen pressure creates showering sparks, use shielding screens to protect nearby areas.

c. Perform cutting on a proper cutting table that provides a work area with a grated surface that permits slags to drop through into a slag box.

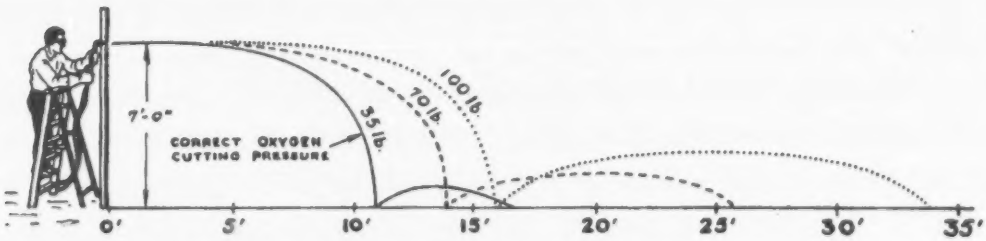
Figure 27

d. Do not cut or weld on a masonry floor because moisture trapped in the masonry can heat rapidly and cause the floor to explode.

e. Because cutting sparks can fly long distances, move flammable material to safe distance from the cutting area.

f. Do not set oxygen pressure too high; too high a setting causes sparks to blow and wastes oxygen too.

Figure 28



Courtesy Modern Engineering Company, Inc.

g. Do not cut into any container because it may still contain the residue of highly explosive materials.

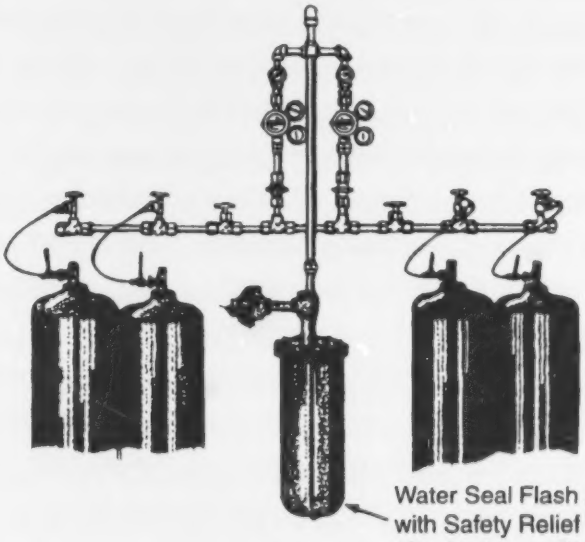
h. Keep cutting as far away from gas cylinders as hose length will permit.

Objective 23

Characteristics of manifold systems

a. Manifolds are systems that pipe oxygen and acetylene from two or more oxygen or acetylene tanks to provide a continuous gas supply when only one cylinder would be inadequate.

Figure 29



b. A manifold system should be large enough to supply volume for the largest size tip used.

c. A manifold should be equipped with a water seal flash arrester on the acetylene side.

d. Manifold systems save space when a number of work stations are required.

e. Manifold systems permit a school or shop to buy gases in quantity, reduce costs, and save money.

f. Fuel gases and liquid oxygen are used in manifold systems in the same way pressurized oxygen and acetylene are used.

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Information Sheet

Objective 24

Characteristics of track-type cutting machines

a. Track-type cutting machines require setup, alignment, and adjustment by an operator.

b. Track-type machines operate on tracks mostly designed for horizontal cutting, but some models have magnetic tracks that permit them to cut in vertical and overhead positions.

c. The carriage is motor-driven and speed is controlled by a governor.

d. Some track-type machines have provisions for mounting two or more torches.

e. Track-type machines are used mostly for making square or beveled cuts, but some machines can be modified with a radius rod to cut circles.

Objective 25

Characteristics of shape cutting machines

a. Machines vary in design from a single wheel to three wheels with attachments for cutting straight lines, bevels, circles, and irregular shapes.

b. Machines are adjustable to many steel forms including rod and pipe, and can be used to cut horizontally or vertically.

c. Machines are controlled by operators who control the speed and direction of a cutting torch that is centered in front of or beside a drive mechanism.

Objective 26

Characteristics of automated cutting machines

a. Automated cutting machines are usually designed for a specific job where the cutting of multiple identical shapes contributes to high productivity.

b. Automated machines function as tracing devices that use a photocell or an electric eye to trace a pattern, or use magnetic devices to trace a metal template.

c. These machines usually have a panel or terminal to give an operator precise control over gas torch operations.

d. These machines are sometimes programmed numerically with punched tape fed into a master control unit, but they are sometimes controlled with solid-state digital devices such as a computer or a programmable logic controller.

Objective 27

Characteristics of pipe beveling machines

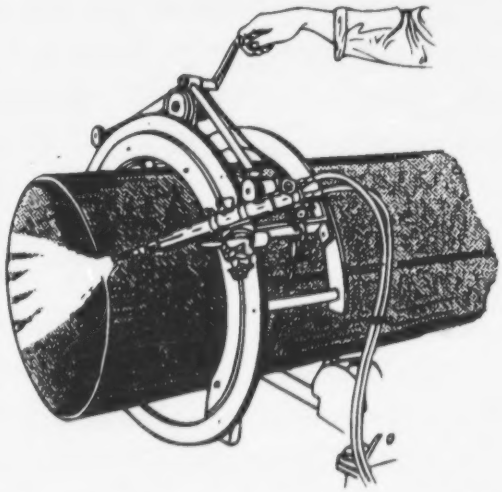
a. Pipe beveling machines are designed specifically for cutting beveled angles, T's and Y's, and other connecting shapes for pipe.

b. Beveling machines may be manually operated or motorized.

c. The basic machine design is a split horseshoe that fits the outside contour of the pipe and is then clamped into position for cutting.

d. Torch holders are designed with easy-to-read protractors for precise control of the cutting angle.

Figure 30



Courtesy H&M Pipe Beveling Machine Company, Inc.

e. A variation of the pipe beveling machine is a device that turns the pipe while the torch holder remains fixed instead of working around the pipe.

Objective 28

Eye protection required for oxyacetylene cutting

a. Wear safety glasses when cleaning or chipping slag from base metal.

b. Wear safety glasses and a face shield when grinding joints or bevels.

c. Wear welding and cutting goggles to protect eyes from spatter, and choose goggles with a lens shade dark enough to protect eyes from intense light rays.

Type of Cutting	Metal Thickness	Shade #
Light	Up to 1″	3 or 4
Medium	1″-6″	4 or 5
Heavy	6″ +	5 or 6

Unit Contents

Student Components

Student Page

Learning Activities Sheet 3–3

Objective Sheet 3–5

Information Sheet 3–7

* Job Sheets

1—Weld a Stringer Bead With a Bronze Rod on Steel Plate 61
2—Braze Weld a Square Groove Butt Joint in the Flat Position . . 65
3—Braze Weld a Lap Joint in the Horizontal Position 69
4—Repair a Worn Tool With Hardfacing 73

* The Job Sheets are located in the Student Workbook

Prerequisites:
None

Learning Activities Sheet

Student Name _____

Place a checkmark in the appropriate box as you complete each of the steps below.

❑	1. **Take**	Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.
❑	2. **Read**	Objective Sheet.
❑	3. **Study**	Information Sheet, Objectives 1 through 25.
❑	4. **View**	Videotape detailing Braze Welding and Surfacing.
❑	5. **Observe**	Demonstration of procedures to be used in completing Job Sheet 1.
❑	6. **Do**	Job Sheet 1, "Weld a Stringer Bead With a Bronze Rod on Steel Plate."
❑	7. **Stop**	Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 8. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 1 and do it again.
❑	8. **Do**	Job Sheet 2, "Braze Weld a Square Butt Joint in the Flat Position", Job Sheet 3, "Braze Weld a Lap Joint in the Horizontal Position," and Job Sheet 4, "Repair a Torn Tool With Hardfacing."
❑	9. **Stop**	After completing each job sheet, have your instructor evaluate your performance and if the evaluation is satisfactory, continue to the next job sheet. If the performance is not satisfactory, study the procedure in that job sheet, and redo the job sheet. After satisfactorily completing all the job sheets, continue to step 10.
❑	10. **Check**	With instructor for any additional assignments to be completed.

❑	11. **Do**	Additional assignments listed below. _____ _____
❑	12. **Take**	Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.
❑	13. **Stop**	Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Objective Sheet

Unit Objective

After completing this unit, the student should be able to weld a stringer bead with a bronze rod on a steel plate, braze weld a butt joint in the flat position and a lap joint in the horizontal position, and repair a worn tool with hardfacing. The student should demonstrate these competencies by completing the job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to oxyacetylene braze welding and surfacing with their definitions.
2. Differentiate between the definitions of *fusion welding* and *braze welding.*
3. Differentiate between the definitions of *brazing* and *braze welding.*
4. Select true statements about the advantages of braze welding.
5. Select true statements about the limitations of braze welding.
6. Complete statements about precoating in braze welding.
7. Select true statements about the purposes of flux.
8. Complete statements about the characteristics of filler rods for braze welding.
9. Complete statements about important factors in successful braze welding.
10. Select true statements about techniques used in preparing joints for braze welding.
11. Complete statements about techniques used to remove oxides in preparing joints for braze welding.
12. Complete statements about techniques used for braze welding steel and cast iron.
13. Match braze welding problems with their causes.
14. Differentiate between the definitions *surfacing* and *hardfacing.*
15. Select true statements about the advantages of bronze surfacing.
16. Complete statements about limitations of bronze surfacing.
17. Differentiate between methods of preparing new and cast iron surfaces

for bronze surfacing.

18. Select true statements about guidelines for bronze surfacing.

19. Select true statements about guidelines for hardfacing applications.

20. Match types of hardfacing alloys with their definitions.

21. Complete statements about hardfacing powders.

22. Complete statements about the advantages of hardfacing with an oxyacetylene torch.

23. Complete statements about guidelines for preparing surfaces for hardfacing.

24. Identify requirements for machining surfaces to be hardfaced.

25. Select true statements about preheating and cooling requirements for hardfacing.

26. Complete statements about techniques used for oxyacetylene hardfacing.

27. Select true statements about techniques for making a second pass when oxyacetylene hardfacing.

28. Complete statements about safety precautions used for hardfacing.

*29. Weld a stringer bead with a bronze rod on steel plate. (Job Sheet 1)

*30. Braze weld a square groove butt joint in the flat position. (Job Sheet 2)

*31. Braze weld a lap joint in the horizontal position. (Job Sheet 3)

*32. Repair a worn tool with hardfacing. (Job Sheet 4)

* Job Sheets are located in the Student Workbook.

Information Sheet

Objective 1

Terms and definitions

a. **Carburizing flame**—A flame with more acetylene than a neutral flame

b. **Flux**—A material used to hinder or prevent the formation of oxide and other undesirable substances in molten metal and on solid metal surface, and to dissolve or otherwise facilitate the removal of such substances

c. **Hardfacing**—A surfacing variation in which surfacing material is deposited to reduce wear

d. **Machining**—Mechanically grinding or milling surfaces, edges, and corners to precise dimensions of a workpiece to be welded; finishing a workpiece after welding

e. **Oxidation**—The chemical reaction of a metal with oxygen in the air in a process that promotes contamination of metal surfaces and eventually leads to rust

f. **Oxidizing flame**—A flame with more oxygen than a neutral flame

g. **Precoating**—Coating the base metal to a joint by dipping, electroplating, or other means prior to soldering or brazing

Note: Precoating is also called *tinning.*

Objective 2

Definitions of *fusion welding* and *braze welding*

a. In fusion welding, the filler rod has a melting point approximately the same as the melting point of the base metal, and both the filler metal and the base metal are melted and fused together.

b. In braze metal, the filler rod has a melting point below the melting point of the base metal, the base metal is never melted, and the weld is formed as a result of gravity pull resulting from weld design.

Objective 3

Definitions of *brazing* and *braze welding*

a. In brazing, the filler metal must have a melting point above 840° F, but lower than the melting point of the base metal, and the filler metal is drawn into a tight-fitting joint by capillary attraction.

b. In braze welding, the filler metal must have a melting point above 840° F, but lower than the melting point of the base metal, and the filler metal is deposited into the joint by gravity pull in the joint design, not by capillary attraction.

Information Sheet

Objective 4

Advantages of braze welding

a. Braze welding is faster than fusion welding because the heat input required is less.

b. Braze welding saves time and reduces fuel gas consumption.

c. Braze welding minimizes preheating requirements.

d. In braze welding, the reduction of heat input has special advantages for welding cast iron because the extremely ductile filler metal can absorb stresses as it cools.

e. Because of a reduction in contraction and expansion, braze welding on steel reduces distortion of the base metal.

f. Braze welding can be used to join dissimilar metals that cannot be fusion welded.

Example: Copper to brass

Objective 5

Limitations of braze welding

a. In braze welding, the weld color cannot match the base metal.

b. Because there is no filler rods for special applications, braze welding cannot be used on metals and joints where high stress is a factor.

c. A braze weld will lose its strength at temperatures above 500° F.

d. A braze weld may have corrosion-resistant properties different from those of the base metal.

e. The strength of a braze weld is limited to the strength of the filler metal.

Objective 6

Statements about precoating in braze welding

a. Braze welding is based on the principle that brass and bronze when raised to the proper temperature will melt and form a smooth precoating film on the surface of a property prepared and heated joint.

b. Precoating cannot be properly accomplished unless the joint has been thoroughly cleaned and properly prepared.

c. Good precoating requires a neutral to slightly reducing flame.

d. Precoating requires a good brazing flux.

e. Improper precoating action is almost always caused by overheating the base metal.

Objective 7

Purposes of flux

a, Flux chemically cleans the base metal.

b. Flux prevents oxidation of the filler metal.

c. Flux floats and removes the oxides already present.

d. Flux increases the flow of the filler metal.

e. Flux increases the ability of the filler metal to adhere to the base metal.

f. Flux brings the filler metal into immediate contact with the metals being joined.

g. Flux permits the filler metal to penetrate the pores of the base metal.

Objective 8

Characteristics of filler rods for braze welding.

a. Filler rods consist of copper alloys containing about 60 percent copper and 40 percent zinc, which:

- Produce a high tensile strength.
- Increase ductility.

b. Filler rods contain small quantities of tin, iron, manganese, and silicon, which help to:

- Deoxidize the weld metal.
- Decrease the tendency to fume.
- Increase the free-flowing action of the molten metal.
- Increase the hardness of the deposited metal for greater wear resistance.

c. Filler rods should be cleaned with emery cloth before use.

Objective 9

Important factors in successful braze welding

a. Cleaning and properly preparing the joint is a must.

b. Proper precoating of the joint is achieved through the cleaning action of the flux and by maintaining proper metal temperature.

c. complete fusion between layers of filler metal is essential when the weld is made in two or more passes.

Information Sheet

Objective 10

Techniques used in preparing joints for braze welding

a. Generally, prepare joints for braze welding as for fusion welding base metals of like thickness.

b. When braze welding base metal no thicker than 1/8″ to 3/16″, you may use square edges.

c. When braze welding metals thicker than 3/16″, use beveled edges.

d. In all cases, thoroughly clean every part of the base metal to be precoated until it is completely free of oxides, oil, and grease.

e. Whenever possible, clean base metal at least 1/2″ back from the edge of the joint.

Objective 11

Techniques used to remove oxides in preparing joints for braze welding

a. Remove oxides mechanically with a wire brush or portable grinder or chemically with a suitable flux.

b. Sometimes to achieve a thorough cleaning of the joint, you must use both chemical and mechanical methods.

Objective 12

Techniques for braze welding steel and cast iron

a. Select a welding tip at least one size smaller than a tip selected for fusion welding a metal of equal thickness.

b. Adjust torch to a neutral or slightly reducing flame.

c. For preheating, move the flame back and forth over a generous area of the base metal until it begins to glow dull red.

d. As the base metal starts to glow dull red, heat the end of the filler rod and dip it in flux until it is well coated.

Note: To flux longer rods, spread the flux out along the inside of the inside corner of a piece of angel iron so the entire length of the rod can be dipped in the flux at one time or use flux-coated rods to eliminate the need for additional flux.

e. As the base metal becomes dull red, move the rod into the flame until it comes in contact with and melts off onto the base metal.

f. When the melted bronze flows smoothly onto the surface of the base metal and flows evenly over a large area, the temperature is just right.

Objective 13

Braze welding problems and their causes

a. Molten bronze forms into drops—Base metal is not yet hot enough

b. Molten bronze tends to bubble and boil—Base metal is too hot

Objective 14

Definitions of *bronze surfacing* and *hardfacing*

a. Bronze surfacing—Braze-welding technique used to rebuild or resurface worn parts

b. Hardfacing—Welding process used to deposit specialized alloys onto parts subject to extensive wear so that the parts become more resistant to abrasion, corrosion, impact, and high temperature

Objective 15

Advantages of bronze surfacing

a. When bronze is applied to steel or cast iron parts subject to sliding friction, the reconditioned parts sometimes give longer service than brand new parts.

Examples: Pistons, rotary valves, and large gears are typical of parts subjected to wear from sliding friction

b. When large pistons have to be replaced, the cost of bronze surfacing is much less than the cost of a new piston, and pistons built this way will sometimes outlast new pistons.

c. Cast iron gears can be rebuilt faster at less cost with bronze welding than with oxyacetylene or arc welding.

Objective 16

Limitations of bronze surfacing

a. Bronze surfacing should not be used on parts such as superheated steam engine pistons that will be subjected to temperatures above 500°F.

b. Bronze surfacing should not be used on parts such as piston rods that will be subjected to alternating tensile and compressive stresses.

Objective 17

Methods of preparing new and cast iron surfaces for bronze surfacing

a. New or almost new surfaces should be machined or ground, or in some cases; just thoroughly cleaned before bronze is applied.

b. Cast iron surfaces should be ground or sand blasted because machining could leave graphite smears that make proper precoating difficult.

Information Sheet

Objective 18

Guidelines for bronze surfacing

a. Remember that bronze surfacing is essentially a braze welding process.

b. When preheating a cast iron part, don't isolate the flame to one spot too long, but move the flame around to distribute heat evenly and avoid cracking the cast iron.

c. When preheating steel, avoid excessive heat build-up in one area or the part could be permanently distorted.

d. Use a neutral or slightly reducing flame and a good brazing flux.

e. To avoid variances in quality, plan the application so that the job can be completed without interruption.

f. Keep the layer of bronze just thick enough so that the lowest spots will still require some finishing machining.

g. Always allow the part to cool slowly to room temperature before machine finishing.

Objective 19

Guidelines for hardfacing applications

a. Hardfacing is usually confined to only that portion of a part that is subject to critical wear, not the entire part.

b. Hardfacing is frequently used on surface areas, edges, or points that are subjected to contact or impact wear.

c. Hardfacing is usually applied over a base metal selected for general strength and economy, but hardfacing alloys are selected for specific wearing conditions.

Objective 20

Definitions to types of hardfacing alloys

a. Low-alloy, iron-base alloys — Materials that are alloyed up to 12 percent with chromium, molybdenum, or manganese

b. High-alloy, iron-base alloys — Materials with 12 to 50 percent alloy content of chromium and sometimes nickel and cobalt

c. Cobalt-base and nickel-base alloys — Materials that contain a small amount of iron, usually cobalt-chromium-tungsten alloys that are expensive but have high resistance to corrosion and oxidation

d. Tungsten-carbide alloys — Materials that combine the qualities of hardness and brittleness required to make manufacturing tools.

Objective 21 **Hardfacing powders and their characteristics**

a. Powders are used primarily on thin base metals that cannot tolerate the heat of conventional arc or oxyacetylene hardfacing.

b. Powders produce deposits so smooth that some parts can be returned to service with no additional machining.

c. Powders may be sprayed on with a spray gun or a hand-held torch assembly, and torch grade powders usually have an improved wetting action.

d. Powders range from nickel-based alloys for general use to cobalt-based alloys where nickel cannot be used.

e. Powders are normally fused onto the base metal with a reducing flame after preheating to 600°-800°F.

Objective 22 **Advantages of hardfacing with an oxyacetylene torch**

a. An oxyacetylene flame can be used with all hardfacing alloys.

b. More pounds per hour can be deposited when hardfacing with arc welding, but dilution of the hardfacing alloys is held to a minimum with an oxyacetylene flame.

c. With an oxyacetylene flame, alloys can be deposited in minimal thicknesses to save expensive materials, and arc processes that can do this are very expensive.

d. An oxyacetylene unit can always be taken to the work, but with other processes the work has to be taken to the welding equipment.

Objective 23 **Guidelines for preparing surfaces for hardfacing**

a. Thoroughly clean surfaces so that they are free of oxides, dirt, oil, or any foreign substance.

b. Because hardfacing applications are limited to specific sections of a part, you must almost always grind or machine a surface.

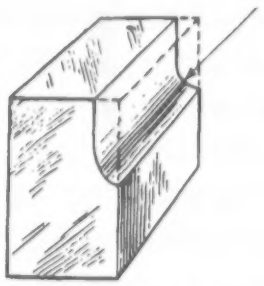
c. Round off all sharp corners.

Objective 24

Requirements for machining surfaces to be hardfaced

a. When a hardfaced edge or corner will be subjected to shock, such as on a punch or shear blade, the steel should be machined as indicated in the following illustration.

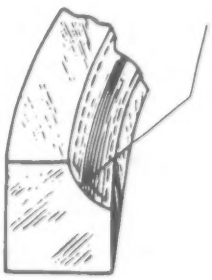
Figure 1



Courtesy Union Carbide Corporation, Linde Division

b. When a hardfaced angle, edge, or corner will not be subjected to heavy impact, the steel should be machined as indicated in the following illustration.

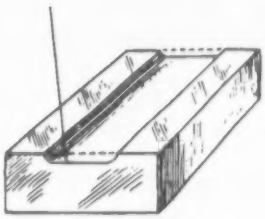
Figure 2



Courtesy Union Carbide Corporation, Linde Division

c. When hardfacing is to be applied to a longitudinal area such as a rolling guide, the steel should be machined with a radii equal to the depth of the groove, as indicated in the following illustration.

Figure 3



Courtesy Union Carbide Corporation, Linde Division

Objective 25

Preheating and cooling requirements for hardfacing

a. Some degree of preheating is required in almost all hardfacing applications.

b. Larger parts must be fully preheated either with a torch or in a preheating furnace.

c. Parts should not be overheated or oxides may form on the surface.

d. Preheating should be applied even to avoid surface cracking in cooling.

e. After hardfacing, the part should be cooled SLOWLY, and this is an extremely important factor in the process.

Figure 4

METAL GROUP	METAL DESIGNATION	C.	RECOMMENDED PREHEAT
PLAIN CARBON STEEL	Plain Carbon Steel	Below .20	Up to 200°F
	Plain Carbon Steel	.20 - .30	200°F - 300°F
	Plain Carbon Steel	.30 - .45	300°F - 500°F
	Plain Carbon Steel	.45 - .80	500°F - 800°F
CARBON MOLY STEELS	Carbon Moly Steel	.10 - .20	300°F - 500°F
	Carbon Moly Steel	.20 - .30	400°F - 600°F
	Carbon Moly Steel	.30 - .35	500°F - 800°F
MANGANESE STEELS	Silicon Structural Steel	.35	300°F - 500°F
	Medium Manganese Steel	.20 - .25	300°F - 500°F
	SAE T 1330 Steel	.30	400°F - 600°F
	SAE T 1340 Steel	.40	500°F - 800°F
	SAE T 1350 Steel	.50	600°F - 900°F
	12% Manganese Steel	1.25	Usually Not Required
HIGH TENSILE STEELS	Manganese Moly Steel	.20	300°F - 500°F
	Manten Steel	.30 Max.	400°F - 600°F
	Armco High Tensile Steel	.12 Max.	Up to 200°F
	Double Strength #1 Steel	.12 Max.	300°F - 600°F
	Double Strength #1A Steel	.30 Max.	400°F - 700°F
	Cr-Cu-Ni Steel	.12 Max.	200°F - 400°F
	Cr-Mn Steel	.40	400°F - 600°F
	Hi-Steel	.12 Max.	200°F - 500°F
NICKEL STEELS	SAE 2015 Steel	.10 - .20	Up to 300°F
	SAE 2115 Steel	.10 - .20	200°F - 300°F
	2½% Nickel Steel	.10 - .20	200°F - 400°F
	SAE 2315 Steel	.15	200°F - 500°F
	SAE 2320 Steel	.20	200°F - 500°F
	SAE 2330 Steel	.30	300°F - 600°F
	SAE 2340 Steel	.40	400°F - 700°F

Objective 26

Techniques used for oxyacetylene hardfacing

a. When working on steel, use a neutral or slightly carburizing flame.

b. After preheating, direct the flame onto the surface of the metal at an angle from 30° to 60° with the tip of the inner core about 1/8" from the surface.

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c. Hold the torch still until the surface sweats and gives a glazed appearance.

d. Withdraw the flame enough so that the end of the rod can be brought between the inner cone and the hot base metal so that the tip of the cone just about touches the rod and the rod touches the sweating surface.

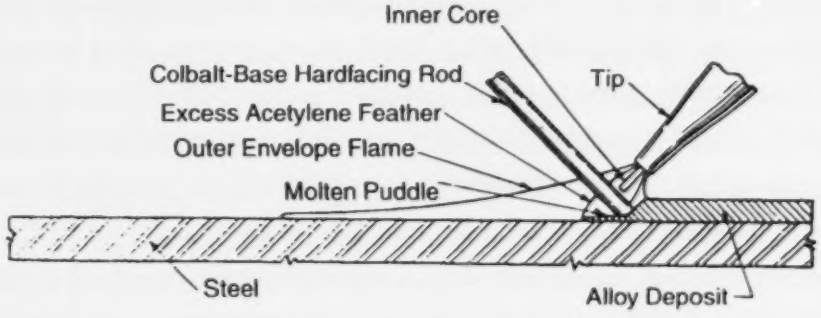
e. As the end of the rod melts and forms a puddle on the surface, make sure the first drop or two spreads out uniformly on the surface, and if it doesn't, the base metal needs more preheating.

f. If the first drops spread uniformly, withdraw the rod from the flame and spread the alloy farther by directing part of the flame on the puddle and part onto surrounding base metal.

g. As the puddle spreads, put the rod into the flame again with its end touching the puddle, and melt more alloy into the puddle.

h. Alternately move the puddle with the flame and reinsert the rod to deposit more alloy until the surface is covered.

Figure 5



Courtesy Union Carbide Corporation, Linde Division

Objective 27

Techniques for making a second pass when oxyacetylene hardfacing

a. After the first pass is completed, the surface will not sweat, so a second pass requires special attention.

b. Move the puddle by flame pressure, not with rod action.

c. Work toward the hand holding the rod, using the forehand technique.

d. When oxides or particles of dirt appear on the surface, try to float them to the surface with the flame, and use the rod to remove particles only when flame action doesn't get the job done.

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e. Cool the part slowly after the final pass is complete.

Note: Controlled cooling is sometimes accomplished by wrapping or burying the part in drive lime, dry sand, or wood ashes; in some shops, furnaces with controlled cooling rates are used, but asbestos coverings should not be used.

f. Finish grinding or machining the part to specifications.

Objective 28

Safety precautions used for hardfacing

a. Observe all safety rules for normal setup and operation of oxyacetylene equipment.

b. Keep work area free of flammable materials and know the location of the nearest fire extinguisher.

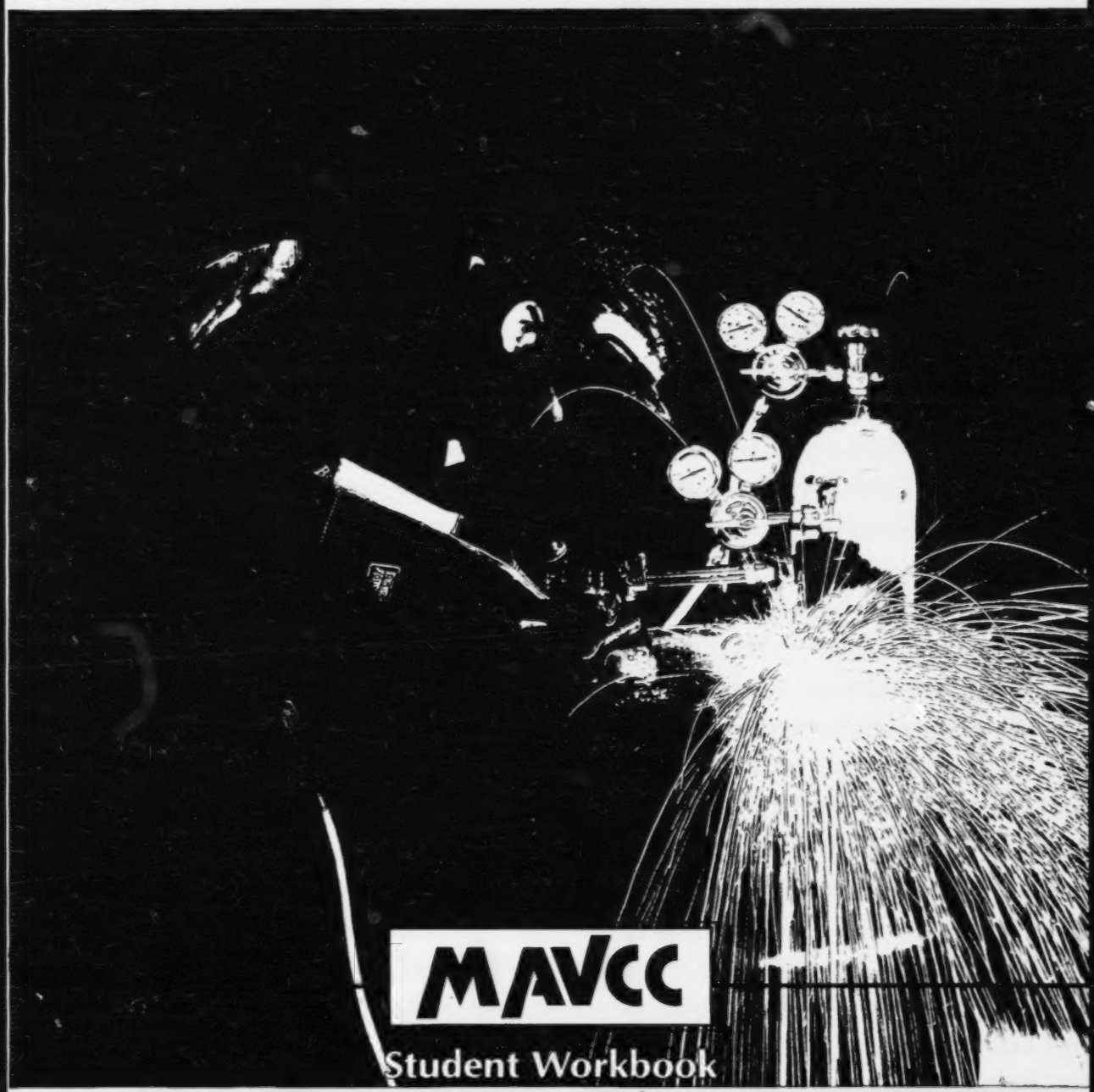
c. Make sure the area is well ventilated because some fluxes used in hard surfacing contain fluorine compounds that become toxic when carbonized.

d. Take special precautions with steels that have white colored coatings or that turn yellow-gold when torch heated; this means cadmium is present in the protective coating and cadmium can generate dangerous fumes as it vaporizes.

e. Before hardfacing parts that have been cleaned with vapor-degreaser, make sure the cleaner has dried and that all fumes have evaporated before.

Oxyacetylene Welding and Oxyfuel Cutting

THIRD EDITION



MAVCC

Student Workbook

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Oxyacetylene Welding and Oxyfuel Cutting

Third Edition

Student Workbook

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Objective 33

Job Sheet 1—Light, Adjust, and Shut Down an Oxyacetylene Welding Torch in Compliance with Safety Standards

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment and workplace safety	_____
• Regulator pressure adjustments	_____
• Purge procedure	_____
• Flame start and flame adjustment	_____
• Shut down procedure	_____

Basic Skills

Reading

Critical Thinking

Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Oxyacetylene cylinders, hoses, and torch assembly
- Sparklighter
- Safety glasses
- Safety goggles
- Welding gloves

Procedure

Caution: Do not carry a propane or butane lighter during this procedure.

❑ 1. Inspect the workplace to make sure it is clear of flammable material and is well ventilated.

❑ 2. Put on welding goggles and welding gloves.

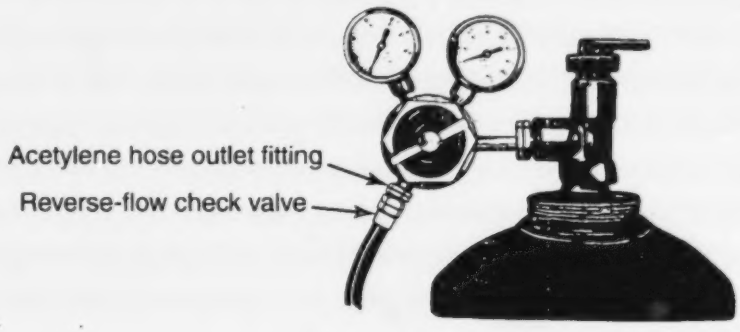
❑ 3. Inspect torch needle valves to make sure they are both turned off.

❑ 4. Inspect both regulator adjusting screws to make sure they are turned fully counterclockwise to prevent sudden pressure from possibly damaging the regulators.

❑ 5. Open the acetylene cylinder slowly about half a turn.

Caution: Never set working pressure on an acetylene regulator gauge above 15 psi because pressure beyond that point could cause the gauge to explode.

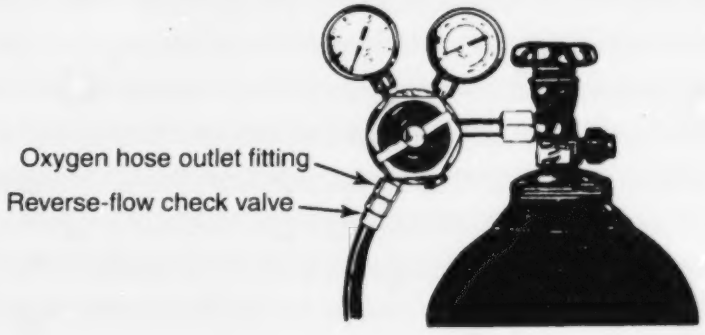
Figure 1



❑ 6. Tighten the adjustment screw on the acetylene regulator by turning it clockwise until the acetylene regulator indicates the recommended tip pressure.

❑ 7. Open the valve on the oxygen cylinder by slowly turning it counterclockwise as far as it will go.

Figure 2



❑ 8. Tighten the adjustment screw on the oxygen regulator by turning it clockwise until the oxygen regulator indicates the recommended tip pressure.

❑ 9. Take the torch in your dominant hand and point the tip down and away from you into a clear, safe area.

❑ 10. Purge both lines with the following procedure:

a. Crack the acetylene needle valve on the torch with your other hand until you hear acetylene escaping from the end of the tip.

Note: At first the acetylene will make an irregular hissing sound, then a low, steady hissing sound that indicates the acetylene line is purged.

b. Look at the acetylene regulator to make sure it remains at recommended pressure.

c. Slowly turn the acetylene needle valve on the torch off.

Note: Develop the habit of opening and closing torch needle valves with care. Forcing them quickly can damage them.

d. Repeat the same procedure with the oxygen line, and make sure the oxygen regulator remains at recommended pressure.

Note: The purging procedure gets impurities out of the lines and assures a steady flow of gases for lighting the torch.

❑ 11. Keep the torch in your dominant hand with the tip pointed down and away from you as you take the sparklighter in your other hand.

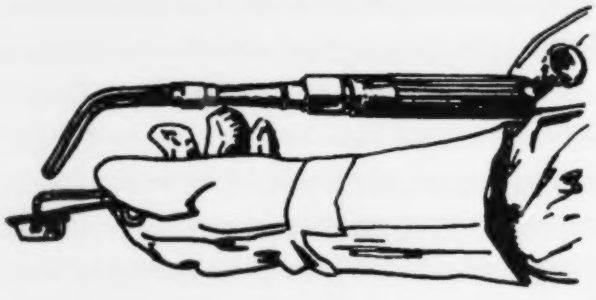
❑ 12. Open the acetylene needle valve on the torch about a quarter turn.

❑ 13. Keep the torch pointed down and away from you.

Note: Acetylene produces a black smoke when it burns, so make the following adjustments as quickly as possible.

❑ 14. Place the sparklighter about one inch below the torch tip, and squeeze it quickly and firmly to make it spark and light the acetylene.

Figure 3



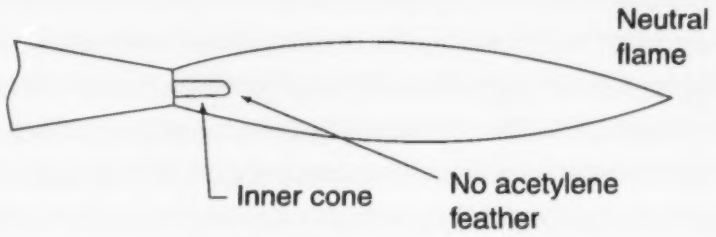
❑ 15. Open the acetylene needle valve on the torch until a blue flame appears, and carbon smoke diminishes.

❑ 16. Open the oxygen needle valve on the torch slowly to allow oxygen to mix with the acetylene.

❑ 17. Continue opening the oxygen needle valve until the mixture and pressure create a sharp inner cone of fire at the torch tip.

Note: Proper adjustment creates a neutral flame and indicates a correct mixture of oxygen and acetylene.

Figure 4



❑ 18. Continue moving the oxygen needle valve slowly into different positions to purposely create improper flames, then readjust for a neutral flame.

Note: This exercise should help you quickly recognize a neutral flame and the adjustments required to create and maintain a neutral flame.

❑ 19. Have your instructor check your flame and pressure settings.

❑ 20. Prepare to shut the equipment down.

❑ 21. Close the oxygen needle valve on the torch.

❑ 22. Close the acetylene needle valve on the torch.

❑ 23. Close the oxygen valve on the cylinder.

❑ 24. Close the acetylene valve on the cylinder.

❑ 25. Open the oxygen needle valve on the torch to bleed the oxygen line.

❑ 26. Allow the oxygen regulator gauge to return to zero, then turn the oxygen regulator adjustment screw counterclockwise until spring tension is released, then close the oxygen needle valve on the torch.

- ❑ 27. Repeat previous steps for the acetylene line.
- ❑ 28. Place hoses and torch back on the welding rack and secure all equipment.
- ❑ 29. Have your instructor check all fuel gas and oxygen control devices.
- ❑ 30. Return welding goggles and welding gloves to proper storage area.

Evaluator's Comments: _____

_____

_____

Objective 34

Job Sheet 2—Lay Beads on Flat Plate with No Filler Rod

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• Neutral flame adjustment	_____
• Flame manipulation and bead quality	_____
• Speed adjustment for heat build-up	_____
• Final bead quality	_____

Basic Skills

Reading

Science

Critical Thinking

Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Oxyacetylene welding unit
- Welding gloves
- Welding goggles and safety glasses
- Pliers
- Sparklighter
- Flat plate steel workpiece as selected by instructor

Procedure

❑ 1. Check work area to make sure it is free of flammable materials and is well ventilated; secure workpiece.

❑ 2. Check thickness of workpiece, select proper tip, and place and tighten tip onto welding torch, finger tight.

❑ 3. Determine regulator pressures required; set up and purge regulators and lines.

❑ 4. Put on gloves and goggles.

❑ 5. Light torch and adjust to a neutral flame according to safety standards previously outlined.

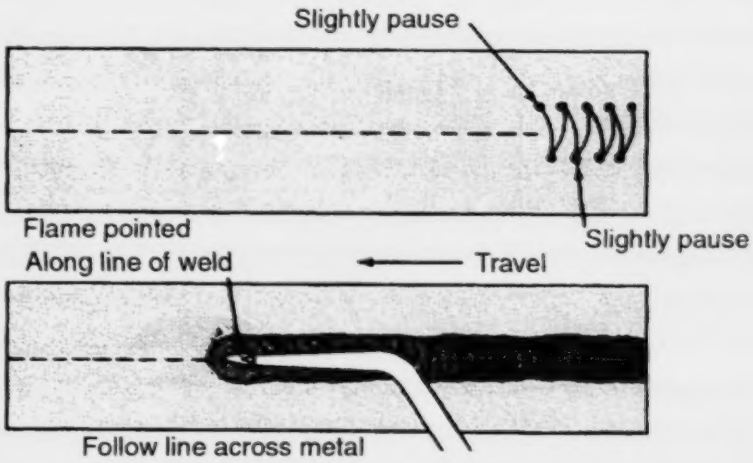
❑ 6. Hold the torch comfortably with either hand and use the forehand welding technique to complete this job sheet.

Note: For a right-handed welder, the forehand technique travels from right to left, and for a left-handed welder, the forehand technique travels from left to right.

❑ 7. Move the torch down until the inner cone of the flame is about 1/8" from the surface of the metal and hold it until a small pool of molten metal forms.

❑ 8. Move the flame back and forth in a series of short arcs or semi-circles while you advance the puddle as steadily as possible across the plate.

Figure 1



❑ 9. Keep puddle oval-shaped and bead as straight as possible as you continue forming the bead.

Note: A thin puddle or bead indicates welding speed is too fast, and a large, round puddle that tends to spark indicates welding speed is too slow or the tip is too close to the workpiece.

❑ 10. Begin compensating for heat build-up after you have finished the first two-thirds of the weld by increasing your welding speed slightly and as weld puddle indicates.

❑ 11. Stop before reaching the end of the weld so molten metal will not drip off the end of the plate.

❑ 12. Leave about 1/2" between welds and start a second weld just below the beginning point of the first weld.

❑ 13. Increase welding speed slightly as you finish the second weld to compensate for heat build-up in the plate.

❑ 14. Finish the second weld and continue making more welds 1/2" apart and parallel with welds one and two.

❑ 15. Observe puddle shape in relation to torch movement at all times and practice making the slight adjustments required in welding speed.

Note: Most beginners are up tight at this point and have white knuckles under their gloves; that's a good time to relax and concentrate completely on the manipulation of the torch and the formation of a well-shaped puddle.

❑ 16. Complete final weld and shut off torch and shut down equipment according to safety standards previously outlined.

❑ 17. Have your instructor check and evaluate your work.

❑ 18. Cool and place all welded scrap material in a proper container and clean area as required.

Note: Develop the habit of conserving materials and saving all scraps that can be used.

❑ 19. Check in tools and materials, or prepare work area for next job sheet, as directed by your instructor.

Evaluator's Comments: _____

_____

_____

Objective 35

Job Sheet 3—Lay Beads on Flat Plate with Filler Rod

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• Neutral flame adjustment	_____
• Torch and rod manipulation	_____
• Puddle shape and movement	_____
• Final bead quality	_____

Basic Skills

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Oxyacetylene welding unit
- Welding gloves
- Welding goggles and safety glasses
- Pliers
- Sparklighter
- Flat plate steel workpiece as selected by instructor
- Mild steel welding rod as selected by instructor

Procedure

❑ 1. Check work area to make sure it is free of flammable materials and is well ventilated; note location of nearest fire extinguisher.

❑ 2. Secure workpiece.

❑ 3. Check thickness of workpiece, select proper tip, and place and tighten tip onto welding torch, finger tight.

❑ 4. Determine regulator pressures required; set up and purge regulators and lines.

❑ 5. Put on gloves and goggles.

❑ 6. Light torch and adjust to a neutral flame according to safety standards previously outlined.

❑ 7. Place the filler rod so that it is half off the work table; while holding the free end of the rod, heat the rod at the midway point until it melts in two.

Note: A shorter rod is easier for a beginner to manipulate and helps eliminate the prospects that someone might walk by and hit the back end of a longer rod and interfere with the welding or maybe injure an eye.

❑ 8. Hold the torch comfortably with one hand, hold the filler rod with the other hand, and use the forehand welding technique to complete this job sheet.

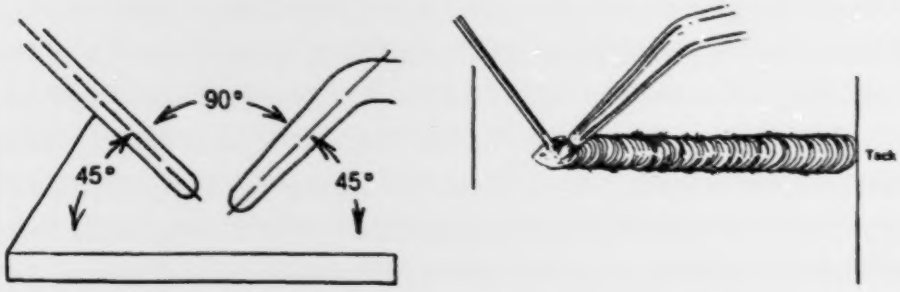
❑ 9. Move the torch down until the inner cone of the flame is about 1/8" from the surface of the metal and hold it there until a small pool of molten metal forms, then begin a slight circular motion with the torch.

❑ 10. Move the rod into the center of the puddle at the point of the inner cone and let a drop or two of molten metal fill the puddle.

❑ 11. Withdraw the rod about 1/2" to 3/4" from the inner cone so that the torch can be moved forward.

❑ 12. Advance the puddle forward with a slight circular motion of the torch and reinsert the rod into the center of the puddle at the point of the inner cone; let a drop or two of molten metal fill the puddle.

Figure 1



❑ 13. Withdraw the rod, advance the torch in a circular motion so that a continuous oval-shaped puddle will form, then reinsert the rod as before and continue the procedure until the first weld is completed.

❑ 14. Stop before reaching the end of the plate so molten metal will not drip off the plate.

❑ 15. Move a short distance down the plate and run another bead parallel to the first weld; continue laying parallel beads as plate space will permit.

Note: Your instructor may direct you to change hands at any point in this activity to give you the feel of working the rod and torch in different hands and to help improve your manipulative skills.

❑ 16. Cool and place all welded scrap material in a proper container and clean area as required.

❑ 17. Have instructor check and evaluate your work.

❑ 18. Check in tools and materials, or prepare work area for next job sheet, as directed by your instructor.

Evaluator's Comments: _____

_____

_____

Objective 36

Job Sheet 4—Weld an Outside Corner Joint in the Flat Position

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• Joint preparation and fit-up	_____
• Neutral flame adjustment	_____
• Proper tack welds	_____
• Torch, rod, and puddle manipulation	_____
• Final bead quality	_____

Basic Skills

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Oxyacetylene welding unit
- Welding gloves
- Welding goggles and safety glasses
- Pliers
- Sparklighter
- Flat plate steel workpiece as selected by instructor
- Mild steel welding rod as selected by instructor

Procedure

❑ 1. Check work area to make sure it is free of flammable materials and is well ventilated; secure workpiece.

❑ 2. Check thickness of workpiece, select proper tip, and place and tighten tip onto welding torch, finger tight.

❑ 3. Determine regulator pressures required; set up and purge regulators and lines.

❑ 4. Check joint to make sure it is properly prepared and properly fitted.

❑ 5. Put on gloves and goggles.

❑ 6. Light torch and adjust to a neutral flame according to safety standards previously outlined.

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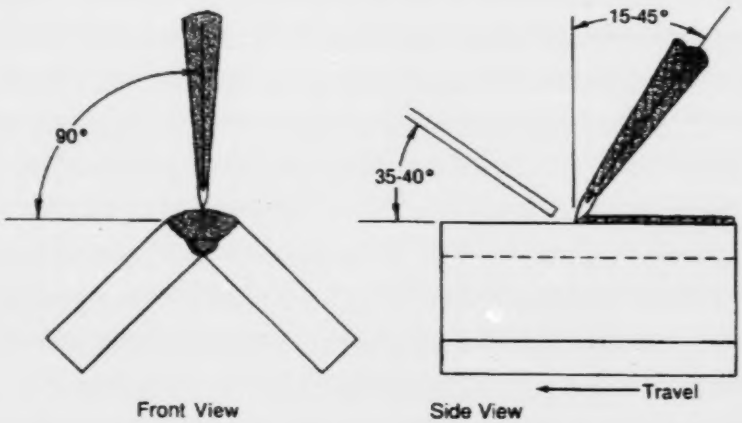
❑ 7. Hold the torch comfortably with one hand, hold the filler rod with the other hand, and use the forehand welding technique to complete this job sheet.

❑ 8. Tack weld joint at each end.

❑ 9. Position torch and rod so that the torch flame points toward the unfinished end of the weld and the rod points toward the finished end of the weld.

Figure 1



❑ 10. Move the torch down until the inner cone of the flame is about 1/8" from the surface of the metal and hold it there until a small pool of molten metal forms, then begin a slight circular motion with the torch.

❑ 11. Move the rod into the center of the puddle at the point of the inner cone; let a drop or two of molten metal fill the puddle as you move the rod in a slight circular motion.

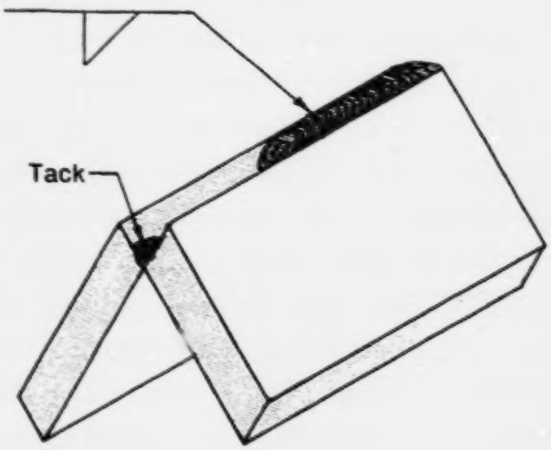
❑ 12. Withdraw the rod about 1/2" to 3/4" from the inner cone so that the torch can be moved forward.

❑ 13. Advance the puddle forward with a slight circular motion of the torch and reinsert the rod into the center of the puddle at the point of the inner cone; let a drop or two of molten metal fill the puddle.

❑ 14. Withdraw the rod, advance the torch in a circular motion so that a continuous oval-shaped puddle will form, then reinsert the rod as before and continue the procedure until the first weld is completed.

Note: In the following illustration, the AWS welding symbol (a fillet weld) for this joint has been added so you can become used to associating welding symbols with the welds they represent.

Figure 2



❑ 15. Stop before reaching the end of the plate so molten metal will not drip off the plate.

❑ 16. Turn off torch.

❑ 17. Inspect weld visually for defects.

❑ 18. Test weld as directed by your instructor.

❑ 19. Have instructor check and evaluate your work.

❑ 20. Check in tools and materials, or prepare work area for next job sheet, as directed by your instructor.

Evaluator's Comments: _____

_____

_____

Objective 37

Job Sheet 5—Weld a Square-Groove Butt Joint in the Flat Position

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• Joint preparation and fit-up	_____
• Neutral flame adjustment	_____
• Proper tack welds	_____
• Torch, rod, and puddle manipulation	_____
• Final bead quality	_____

Basic Skills

Reading

Science

Critical Thinking

Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Oxyacetylene welding unit
- Welding gloves
- Welding goggles and safety glasses
- Pliers
- Sparklighter
- Flat plate steel workpiece as selected by instructor
- Mild steel welding rod as selected by instructor

Procedure

❑ 1. Check work area to make sure it is free of flammable materials and is well ventilated; secure workpiece.

❑ 2. Check thickness of workpiece, select proper tip, and place and tighten tip onto welding torch, finger tight.

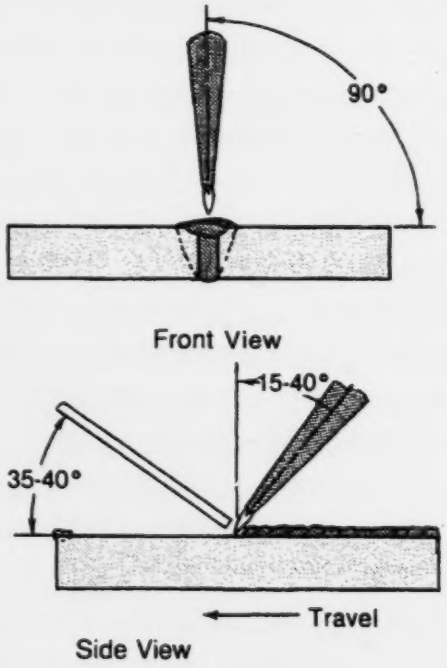
❑ 3. Determine regulator pressures required; set up and purge regulators and lines.

❑ 4. Check joint to make sure it is properly prepared and use a welding rod as a gap wire to be sure the joint is properly fitted.

❑ 5. Put on gloves and goggles.

- ❑ 6. Light torch and adjust to a neutral flame according to safety standards previously outlined.
- ❑ 7. Hold the torch comfortably with one hand, hold the filler rod with the other hand, and use the forehand welding technique to complete this job sheet.
- ❑ 8. Tack weld joint at each end.
- ❑ 9. Position torch and rod so that the torch flame points toward the unfinished end of the weld and the rod points toward the finished end of the weld.

Figure 1



- ❑ 10. Move the torch down until the inner cone of the flame is about 1/8" from the surface of the metal and hold it there until a small pool of molten metal forms, then begin a slight circular motion with the torch.
- ❑ 11. Move the rod into the center of the puddle at the point of the inner cone; let a drop or two of molten metal fill the puddle as you move the rod in a slight circular motion.
- ❑ 12. Withdraw the rod about 1/2" to 3/4" from the inner cone so that the torch can be moved forward.

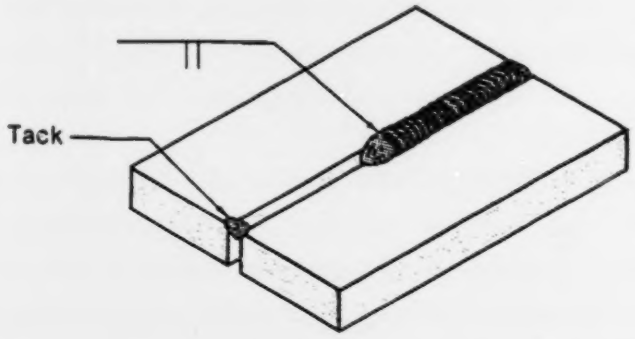
BEST COPY AVAILABLE

❑ 13. Advance the puddle forward with a slight circular motion of the torch and reinsert the rod into the center of the puddle at the point of the inner cone; let a drop or two of molten metal fill the puddle as you move the rod in a circular motion.

❑ 14. Withdraw the rod, advance the torch in a circular motion so that a continuous oval-shaped puddle will form, then reinsert the rod as before and continue the procedure until the first weld is complete.

Note: In the following illustration, the AWS welding symbol (square groove) for this joint has been added so you can become used to associating welding symbols with the welds they represent.

Figure 2



❑ 15. Stop at the tack weld before reaching the end of the plate so molten metal will not drip off the plate.

❑ 16. Turn off torch.

❑ 17. Inspect weld visually for defects.

❑ 18. Test weld as directed by your instructor.

❑ 19. Have instructor check and evaluate your work.

❑ 20. Check in tools and materials, or prepare work area for next job sheet, as directed by your instructor.

Evaluator's Comments: _____

_____

_____

Objective 38

Job Sheet 6—Weld a Lap Joint in the Flat Position

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• Joint preparation and fit-up	_____
• Neutral flame adjustment	_____
• Proper tack welds	_____
• Torch, rod, and puddle manipulation	_____
• Final bead quality	_____

Basic Skills

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Oxyacetylene welding unit
- Welding gloves
- Welding goggles and safety glasses
- Pliers
- Sparklighter
- Flat plate steel workpiece as selected by instructor
- Mild steel welding rod as selected by instructor

Procedure

❑ 1. Check work area to make sure it is free of flammable materials and is well ventilated; note location of nearest fire extinguisher.

❑ 2. Check thickness of workpiece, select proper tip, and place and tighten tip onto welding torch, finger tight.

❑ 3. Determine regulator pressures required; set up and purge regulators and lines.

❑ 4. Check joint to make sure it is properly prepared and properly fitted.

❑ 5. Put on gloves and goggles.

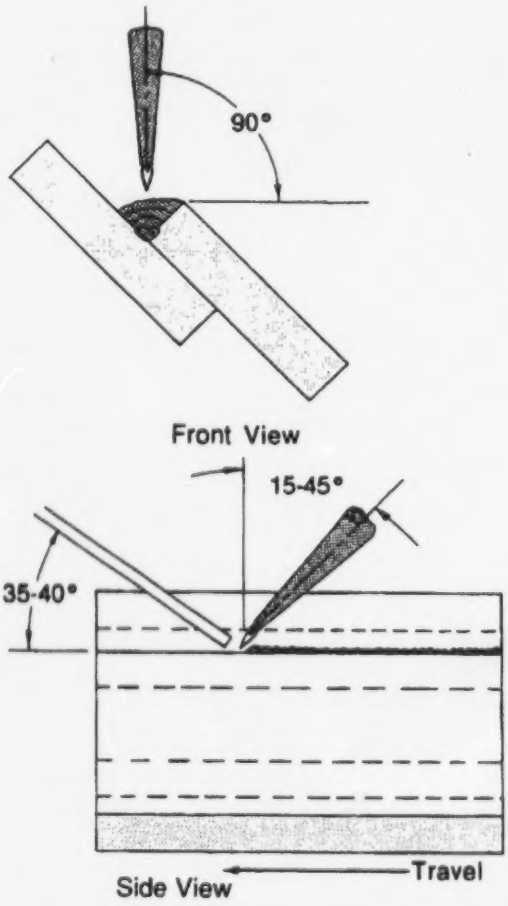
❑ 6. Light torch and adjust to a neutral flame according to safety standards previously outlined.

❑ 7. Hold the torch comfortably with one hand, hold the filler rod with the other hand, and use the forehand welding technique to complete this job sheet.

❑ 8. Tack weld joint at each end.

❑ 9. Position torch and rod so that the torch flame points toward the unfinished end of the weld and the rod points toward the finished end of the weld.

Figure 1



❑ 10. Move the torch down until the inner cone of the flame is about 1/8" from the surface of the metal and hold it there until a small pool of molten metal forms, then begin a slight circular motion with the torch.

❑ 11. Move the rod into the center of the puddle at the point of the inner cone; let a drop or two of molten metal fill the puddle as you move the rod in a slight circular motion.

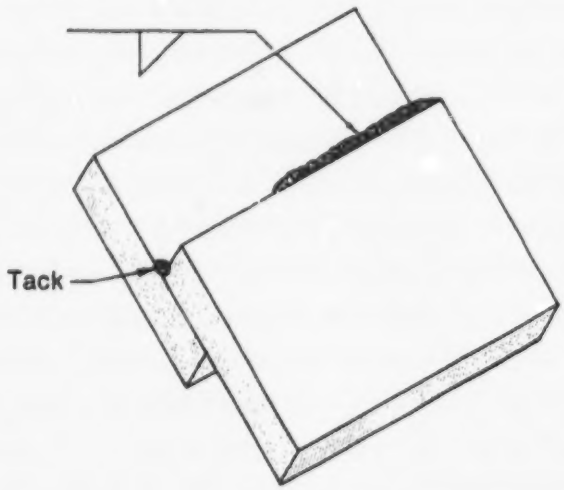
❑ 12. Withdraw the rod about 1/2" to 3/4" from the inner cone so that the torch can be moved forward.

❑ 13. Advance the puddle forward with a slight circular motion of the torch and reinsert the rod into the center of the puddle at the point of the inner cone; let a drop or two of molten metal fill the puddle as you move the rod in a circular motion.

❑ 14. Withdraw the rod, advance the torch in a circular motion so that a continuous oval-shaped puddle will form, then reinsert the rod as before and continue the procedure until the first weld is completed.

Note: In the following illustration, the AWS welding symbol (a fillet weld) for this joint has been added so you can become used to associating welding symbols with the welds they represent.

Figure 2



❑ 15. Stop at the tack weld before reaching the end of the plate so molten metal will not drip off the plate.

❑ 16. Turn off torch.

❑ 17. Inspect weld visually for defects.

❑ 18. Test weld as directed by your instructor.

❑ 19. Have instructor check and evaluate your work.

❑ 20. Check in tools and materials, or prepare work area for next job sheet, as directed by your instructor.

Evaluator's Comments: _____

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Objective 39

Job Sheet 7—Weld a T-Joint in the Flat Position

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• Joint preparation and fit-up	_____
• Neutral flame adjustment	_____
• Proper tack welds	_____
• Torch, rod, and puddle manipulation	_____
• Final bead quality	_____

Basic Skills

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Oxyacetylene welding unit
- Welding gloves
- Welding goggles and safety glasses
- Pliers
- Sparklighter
- Flat plate steel workpiece as selected by instructor
- Mild steel welding rod as selected by instructor

Procedure

❑ 1. Check work area to make sure it is free of flammable materials and is well ventilated; note location of nearest fire extinguisher.

❑ 2. Check thickness of workpiece, select proper tip, and place and tighten tip onto welding torch, finger tight.

❑ 3. Determine regulator pressures required; set up and purge regulators and lines.

❑ 4. Check joint to make sure it is properly prepared and properly fitted.

❑ 5. Put on gloves and goggles.

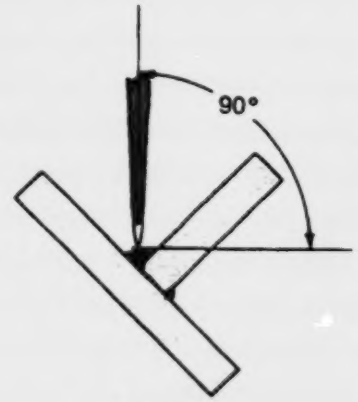
❑ 6. Light torch and adjust to a neutral flame according to safety standards previously outlined.

❑ 7. Hold the torch comfortably with one hand, hold the filler rod with the other hand, and use the forehand welding technique to complete this job sheet.

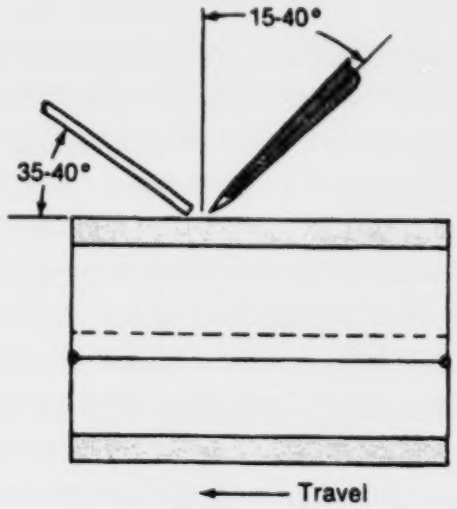
❑ 8. Tack weld joint at each end.

❑ 9. Position torch and rod so that the torch flame points toward the unfinished end of the weld and the rod points toward the finished end of the weld.

Figure 1



Front View



Side View

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❑ 10. Move the torch down until the inner cone of the flame is about 1/8" from the surface of the metal and hold it there until a small pool of molten metal forms, then begin a slight circular motion with the torch.

❑ 11. Move the rod into the center of the puddle at the point of the inner cone; let a drop or two of molten metal fill the puddle as you move the rod in a slight circular motion.

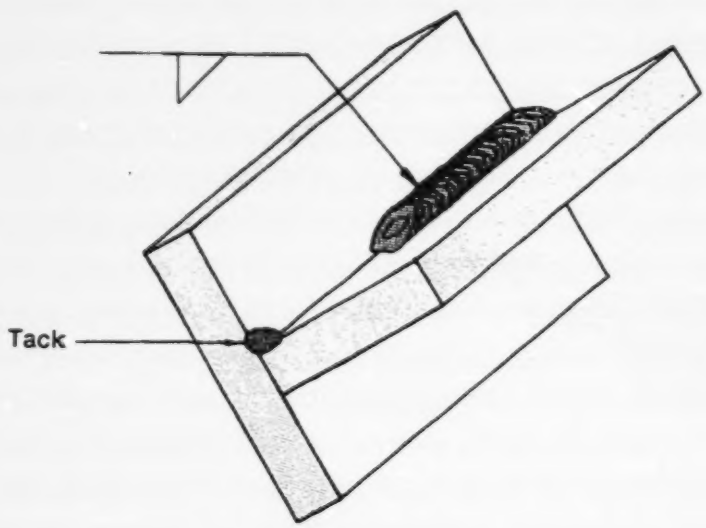
❑ 12. Withdraw the rod about 1/2" to 3/4" from the inner cone so that the torch can be moved forward.

❑ 13. Advance the puddle forward with a slight circular motion of the torch and reinsert the rod into the center of the puddle at the point of the inner cone; let a drop or two of molten metal fill the puddle as you move the rod in a circular motion.

❑ 14. Withdraw the rod, advance the torch in a circular motion so that a continuous oval-shaped puddle will form, then reinsert the rod as before and continue the procedure until the first weld is completed.

Note: In the following illustration, the AWS welding symbol (a fillet weld) for this joint has been added so you can become used to associating welding symbols with the welds they represent.

Figure 2



❑ 15. Stop at the tack weld before reaching the end of the plate so molten metal will not drip off the plate.

❑ 16. Turn off torch.

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- ❑ 17. Inspect weld visually for defects.
- ❑ 18. Have instructor check and evaluate your work.
- ❑ 19. Check in tools and materials, or prepare work area for next job sheet, as directed by your instructor.

Evaluator's Comments: _____

_____

_____

Objective 29

Job Sheet 1—Set Up, Adjust Cutting Flame, and Shut Down Oxyacetylene Cutting Equipment

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• Neutral flame adjustment	_____
• Cutting flame adjustment	_____
• Equipment shut down and safety	_____

Basic Skills

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Oxygen cylinder
- Acetylene cylinder
- Oxygen regulator
- Acetylene regulator
- Hoses and check valves
- Wrench
- Cylinder holder
- Torch body with tips
- Leak detector
- Cutting goggles and safety glasses

Procedure

❑ 1. Fasten cylinders in a vertical position.

❑ 2. Remove caps from cylinders.

❑ 3. Crack valves of each cylinder momentarily, then close valves.

❑ 4. Connect oxygen regulator to oxygen cylinder.

❑ 5. Turn the adjusting screw on the oxygen regulator counterclockwise until tension on the spring is released.

❑ 6. Connect the acetylene regulator to the acetylene cylinder.

- ❑ 7. Turn the adjusting screw on the acetylene regulator counterclockwise until tension on the spring is released.
- ❑ 8. Connect the oxygen hose to the oxygen check valve, and then connect the check valve to the oxygen regulator.
- ❑ 9. Connect the acetylene hose to the acetylene check valve, and then connect the check valve to the acetylene regulator.

  Note: Check valves can be installed between hoses and torch body.
- ❑ 10. Connect the oxygen and acetylene hoses to the torch body, and then close both needle valves on the torch body.
- ❑ 11. Select tip size according to the thickness of metal to be cut, and the tip manufacturer's recommendations; attach tip to cutting attachment.
- ❑ 12. Attach the cutting attachment to the torch body.
- ❑ 13. Double check to make sure the oxygen and acetylene needle valves and the oxygen preheat valve are all closed.
- ❑ 14. Turn the oxygen cylinder valve slowly wide open.
- ❑ 15. Turn the acetylene cylinder valve slowly one half to three quarters of a turn.
- ❑ 16. Turn the adjusting screw on the oxygen regulator clockwise until the regulator indicates the correct working pressure.
- ❑ 17. Turn the adjusting screw on the acetylene regulator clockwise until the regulator indicates the correct working pressure.
- ❑ 18. Use a safe leak detector to test all connections for leaks.
- ❑ 19. Have your instructor check your work.
- ❑ 20. Open the oxygen needle valve on the torch to a full open position and then open the acetylene needle valve half a turn.
- ❑ 21. Light the torch with a flint lighter.
- ❑ 22. Open oxygen preheat valve slowly and adjust to a neutral flame and readjust acetylene needle valve if necessary.

- ❑ 23. Depress the oxygen cutting lever and check to see that a neutral flame is still present.
- ❑ 24. Keep the oxygen cutting lever depressed and adjust the oxygen preheat valve until you have a neutral flame.
- ❑ 25. Have your instructor check the cutting flame.
- ❑ 26. Release oxygen cutting lever and begin shut down.
- ❑ 27. Close the oxygen preheat needle valve on the cutting attachment.
- ❑ 28. Close the acetylene needle valve on the torch body.
- ❑ 29. Close the oxygen valve on the cylinder.
- ❑ 30. Close the acetylene valve on the cylinder.
- ❑ 31. Press the oxygen cutting lever to release pressure from the oxygen regulator and hose, and then release the cutting lever.
- ❑ 32. Turn the oxygen regulator adjustment screw counterclockwise.
- ❑ 33. Close the oxygen needle valve on the torch body.
- ❑ 34. Open the acetylene needle valve on the torch body to release pressure from the acetylene regulator and hose, and then close the acetylene needle valve.
- ❑ 35. Turn the acetylene regulator adjustment screw counterclockwise to release spring tension.
- ❑ 36. Have your instructor check your shut down.
- ❑ 37. Check in tools and materials as directed by your instructor.

Evaluator's Comments: _____

_____

_____

Objective 30

Job Sheet 2—Set Up, Adjust Cutting Flame For Star Pattern,and Shut Down Oxyfuel Cutting Equipment

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• Neutral flame adjustment	_____
• Star pattern cutting flame adjustment	_____
• Equipment shut down and safety	_____

Basic Skills

Reading

Critical Thinking

Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Oxygen cylinder
- Fuel gas cylinder
- Oxygen regulator
- Fuel gas regulator
- Injector torch and tip (optional)
- Equal pressure/positive pressure torch and tip
- Hoses and check valves
- Wrench
- Cylinder holder
- Leak detector
- Cutting goggles and safety glasses

Procedure

❑ 1. Fasten cylinders in a vertical position.

❑ 2. Remove caps from cylinders.

❑ 3. Crack valves of each cylinder momentarily; then close valves.

❑ 4. Connect oxygen regulator to oxygen cylinder.

❑ 5. Turn the adjusting screw on the oxygen regulator counterclockwise until tension on the spring is released.

❑ 6. Connect the fuel gas regulator to the fuel gas cylinder.

❑ 7. Turn the adjusting screw on the fuel gas regulator counterclockwise until tension on the spring is released.

Note: The following procedures will vary with the type of cutting torch you are using. If you use an a positive pressure or equal-pressure torch, follow steps 8 through 25. If you are using an injector torch, follow steps 26 through 29.

❑ 8. Connect the oxygen hose to the oxygen check valve, and then connect the check valve to th,e oxygen regulator.

❑ 9. Connect the fuel gas hose to the fuel gas check valve, and then connect the check valve to the fuel gas regulator.

Note: Check valves can be installed between hoses and torch body.

❑ 10. Connect the oxygen and fuel gas hoses to the torch body, and then close both needle valves on the torch body.

❑ 11. Select tip size according to the thickness of metal to be cut, and the tip manufacturer's recommendations; attach tip to cutting attachment.

❑ 12. Attach the cutting attachment to the torch body.

❑ 13. Double check to make sure the oxygen and fuel gas needle valves and the oxygen preheat valve are all closed.

❑ 14. Turn the oxygen cylinder valve slowly wide open.

❑ 15. Turn the fuel gas cylinder valve slowly one half to three quarters of a turn.

❑ 16. Turn the adjusting screw on the oxygen regulator clockwise until the regulator indicates the correct working pressure.

❑ 17. Turn the adjusting screw on the fuel gas regulator clockwise until the regulator indicates the correct working pressure.

❑ 18. Use a safe leak detector to test all connections for leaks.

❑ 19. Have your instructor check your work.

Note: In the following procedure you are working with fuel gas, not acetylene. The procedure is also for a positive pressure or equal pressure torch. Follow instructions carefully and if you have questions, ask your instructor for help.

❑ 20. Open the fuel gas needle valve on the torch enough to let gas flow through the torch.

❑ 21. Light the fuel gas and then add oxygen slowly to stabilize the flame.

❑ 22. Repeat the procedure to force as much fuel through the tip as possible.

❑ 23. Adjust to a neutral flame by increasing the oxygen until the inner preheat cones are reduced to their shortest length.

❑ 24. Check to see that you have a proper fuel gas neutral flame with the following procedure:

- ❑ a. Point the torch flame onto a flat piece of scrap steel plate.
- ❑ b. A short, sharp star pattern of flames indicates too much oxygen or an oxidizing flame.
- ❑ c. A long, bushy pattern of flames indicates a lack of oxygen or a reducing flame.
- ❑ d. A well-defined star pattern of 2 to 3 inches indicates a proper neutral flame.

❑ 25. Have your instructor check your cutting flame and continue with steps 30 through 41 to safely shut down the system.

Note: The following lighting and adjustment procedure is designed for use with an injector cutting torch.

❑ 26. Set up both regulators as previously outlined.

❑ 27. Turn on fuel gas and then quickly turn on the oxygen and immediately light the torch.

❑ 28. Adjust for a neutral flame by checking for a proper star pattern when the flame is directed onto a scrap piece of plate steel.

❑ 29. Adjust oxygen and fuel gas as required for the proper neutral flame.

Note: In practice, if you cut with a fuel gas, you should keep the torch farther from the base metal than when using acetylene. This means a distance of 1/4″ to 3/4″ as opposed to a distance of 1/8″ with acetylene. When a fuel gas flame is too close to the base metal it does not produce optimum preheat and may even cause molten metal to plug the tip.

❑ 30. Release oxygen cutting lever and begin shut down.

- ❑ 31. Close the oxygen preheat needle valve on the cutting attachment.
- ❑ 32. Close the fuel gas needle valve on the torch body.
- ❑ 33. Close the oxygen valve on the cylinder.
- ❑ 34. Close the fuel gas valve on the cylinder.
- ❑ 35. Press the oxygen cutting lever to release pressure from the oxygen regulator and hose, and then release the cutting lever.
- ❑ 36. Turn the oxygen regulator adjustment screw counterclockwise.
- ❑ 37. Close the oxygen needle valve on the torch body.
- ❑ 38. Open the fuel gas needle valve on the torch body to release pressure from the acetylene regulator and hose, and then close the fuel gas needle valve.
- ❑ 39. Turn the fuel gas regulator adjustment screw counterclockwise to release spring tension.
- ❑ 40. Have your instructor check your shut down.
- ❑ 41. Check in tools and materials as directed by your instructor.

Evaluator's Comments: _____

_____

_____

Objective 31

Job Sheet 3—Make 90° Cuts and Restart a Cut On Mild Steel

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• Cutting flame adjustment	_____
• Torch angle and torch manipulation	_____
• Quality of 90° angle	_____
• Preheat for restart	_____
• Quality of restart	_____
• Equipment shut down and safety	_____

Basic Skills

Reading

Critical Thinking

Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Cutting outfit with tip assembly
- Mild steel plate as selected by instructor
- Soapstone with a sharp point or edge
- Straightedge
- Gloves
- Welding goggles and safety glasses
- Pliers
- Protective clothing
- Flint lighter
- Welding or cutting torch
- Slag box
- Can of water
- Cutting tip

Procedure

❑ 1. Mark four parallel lines 2″ apart on plate to be cut.

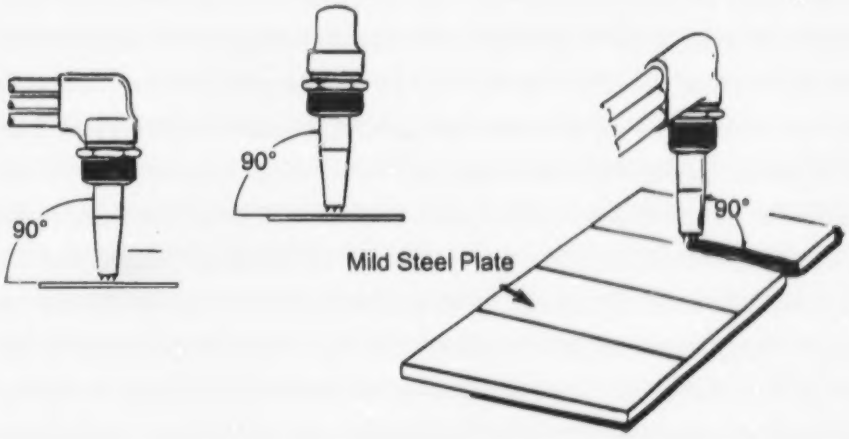
❑ 2. Adjust oxygen regulator.

❑ 3. Adjust acetylene regulator.

❑ 4. Place plate to be cut on cutting table.

- ❑ 5. Light torch.
- ❑ 6. Adjust to neutral flame.
- ❑ 7. Assume comfortable position.
- ❑ 8. Place hoses behind operator.
- ❑ 9. Maneuver torch with both hands.
- ❑ 10. Hold preheat flame with tip of inner cone 1/16″ to 1/8″ above top of plate at right edge until reddish-yellow spot appears.
- ❑ 11. Depress the oxygen cutting lever, and move from right to left across the plate (for left-handed operators, go from left to right).

Figure 1



- ❑ 12. Hold the tip at right angles to work while maintaining correct inner cone distance.
- ❑ 13. Make 90° cuts until you have developed the proper procedure.
- ❑ 14. Release the oxygen cutting lever, and turn the torch off.
- ❑ 15. Use pliers to dip the plates in water to cool them.
- ❑ 16. Have your instructor check your 90° cuts.
- ❑ 17. Secure one of the plates and start a cut, stopping approximately midway through the cut.

- ❑ 18. Release the cutting lever.
- ❑ 19. Preheat the edge where the cutting stopped.
- ❑ 20. Depress the oxygen cutting lever slowly and restart the cut.
- ❑ 21. Complete the cut and shut down equipment as previously outlined.
- ❑ 22. Have your instructor check your restart.
- ❑ 23. Check in tools and materials as directed by your instructor.

Evaluator's Comments: _____

_____

_____

Objective 32

Job Sheet 4—Make a Flame-Beveled Cut On Mild Steel Plate

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• Neutral flame adjustment	_____
• Cutting flame adjustment	_____
• Torch and cutting flame manipulation	_____
• Equipment shut down and safety	_____

Basic Skills

Reading

Critical Thinking

Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Cutting outfit with tip assembly
- Mild steel plate as selected by instructor
- Soapstone with a sharp point or edge
- Straightedge
- Gloves
- Welding goggles and safety glasses
- Pliers
- Protective clothing
- Flint lighter
- Welding or cutting table
- Slag box
- Can of water
- Cutting tip

Procedure

❑ 1. Place mild steel plate on cutting table.

❑ 2. Light and adjust cutting torch to a neutral flame.

Note: Oxygen cutting pressures are greater for bevel cuts than 90° cuts.

❑ 3. Place hoses behind operator.

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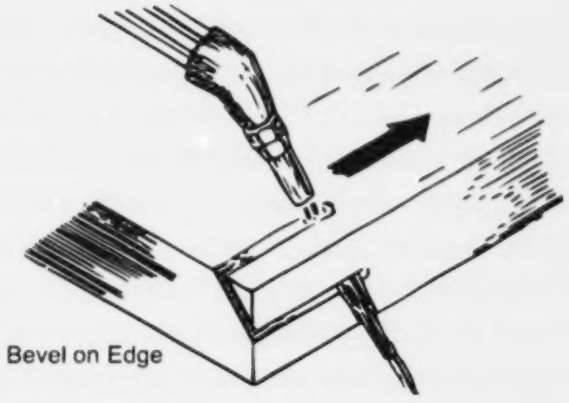
❑ 4. Hold torch with both hands at desired angle to metal as shown.

Figure 1



❑ 5. Hold preheat flame with tip of inner cone (neutral fame) 1/16″ to 1/8″ above top of plate until red spot appears.

❑ 6. Depress the oxygen cutting lever and proceed across the plate with very consistent movement, being careful to maintain constant travel speed, torch angle, and flame-to-work distance.

❑ 7. Practice until you have developed the proper procedure.

❑ 8. Have your instructor check your work.

❑ 9. Check in tools and materials as directed by your instructor.

Evaluator's Comments: _____

_____

_____

Objective 33

Job Sheet 5—Cut Holes in Mild Steel

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• Neutral flame adjustment	_____
• Flame and torch manipulation to pierce plate	_____
• Flame and torch manipulation to cut circles	_____
• Quality of cut holes	_____

Basic Skills

Reading

Critical Thinking

Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Cutting outfit with tip assembly
- Mild steel plate as selected by instructor
- Soapstone with a sharp point or edge
- Straightedge
- Gloves
- Welding goggles and safety glasses
- Pliers
- Protective clothing
- Flint lighter
- Welding or cutting table
- Slag box
- Can of water

Procedure

❑ 1. Draw circles on metal with soapstone.

- ❑ a. 1˝ in diameter, 1˝ from edge
- ❑ b. 1/2˝ in diameter, 1˝ from edge

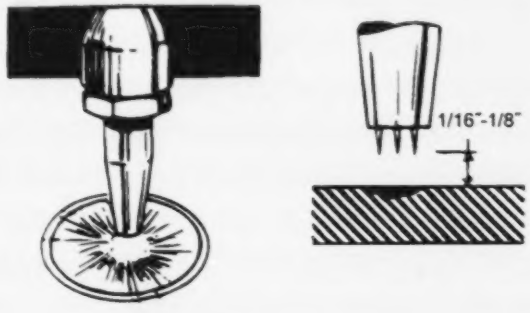
❑ 2. Adjust oxygen regulator.

❑ 3. Adjust acetylene regulator.

❑ 4. Place metal to be cut on cutting table.

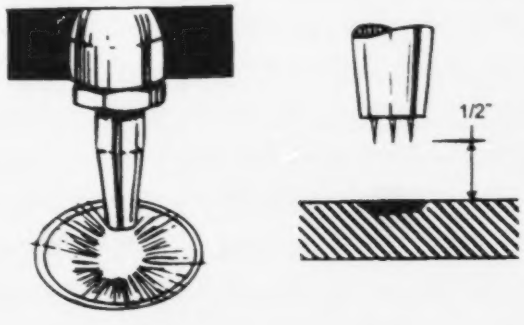
- ❑ 5. Light torch
- ❑ 6. Adjust to neutral flame
- ❑ 7. Assume comfortable position
- ❑ 8. Place hoses behind operator
- ❑ 9. Maneuver torch with both hands.
- ❑ 10. Hold tip of inner cone 1/16˝ ti 1/8˝ above point to be cut until metal turns reddish-yellow

Figure 1



- ❑ 11. After the metal turns reddish-yellow, raise the inner cone approximately 1/2˝ above the point to be cut

Figure 2



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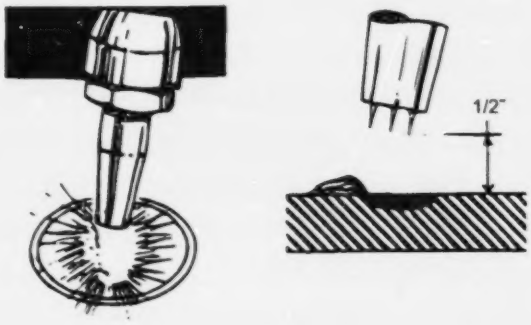
❑ 12. Tilt the torch 15° from the vertical position so that molten metal will be blown away from the operator.

Figure 3



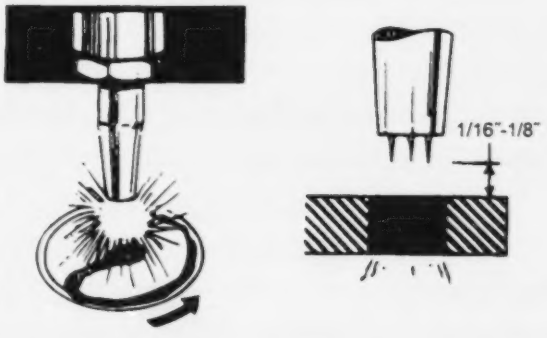
❑ 13. Depress the oxygen cutting lever slowly, moving the torch backwards (to the operator's right, if right handed) until the flame pierces the plate.

❑ 14. Return the torch to the vertical position.

❑ 15. Lower the cutting tip until the tip of the inner cone is 1/16" to 1/8" above the plate.

❑ 16. Make the cut.

Figure 4



❑ 17. Cut just inside soapstone mark until circular cut is completed.

❑ 18. Repeat required steps until both holes are cut.

❑ 19. Use pliers to hold metal, and place metal in a can of water to cool.

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❑ 20. Have your instructor check your work.

❑ 21. Check in tools and equipment and clean area.

Evaluator's Comments: _____

_____

_____

Objective 34

Job Sheet 6—Lay Out a Pattern on Mild Steel and Cut the Pattern to Specifications

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• Plate marking and preparations	_____
• Neutral flame adjustment	_____
• Straight cuts to specifications	_____
• Beveled cuts to specifications	_____

Basic Skills

Reading

Critical Thinking

Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Square and straightedge
- Soapstone
- Mild steel plate 1/4˝ to 1/2˝ thick
- 6˝ square
- Gloves
- Welding goggles and safety glasses
- Protective clothing
- Pliers
- Chipping hammer
- Cutting equipment

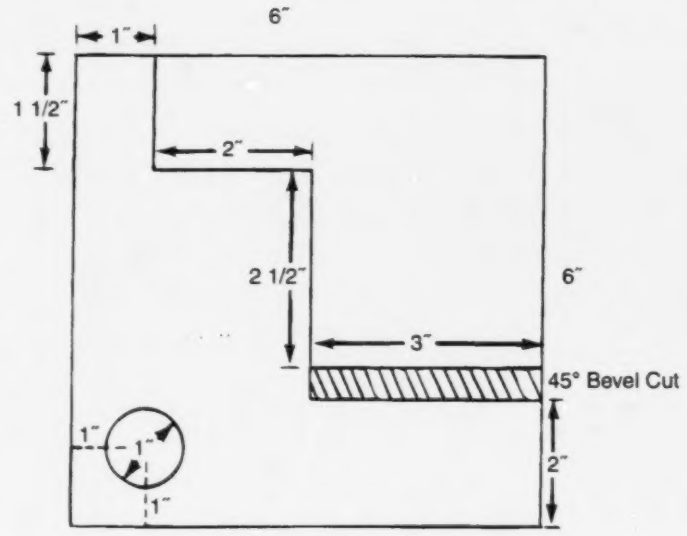
Procedure

❑ 1. Select starting point.

❑ 2. Measure distances and mark as indicated in following illustration.

❑ 3. Have instructor check your layout.

Figure 1



- ❑ 4. Place plate on cutting table.
- ❑ 5. Set up cutting equipment and select appropriate tip for thickness of metal.
- ❑ 6. Light and adjust cutting torch flame.
- ❑ 7. Make straight cut or bevel cuts as required to cut pattern to specifications.
- ❑ 8. Turn off torch.
- ❑ 9. Secure hot workpiece with pliers and quench to cool.
- ❑ 10. Have your instructor evaluate your slag cuts.
- ❑ 11. Chip slag and then inspect for proper torch angles, drag lines, and straightness.
- ❑ 12. Have your instructor check your work.
- ❑ 13. Shut down cutting equipment.
- ❑ 14. Check in tools and equipment and clean area.

Evaluator's Comments: _____

_____

_____

Objective 35

Job Sheet 7—Set Up and Cut a 30° Bevel With a Track-Type Torch

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• Pipe positioning	_____
• Use of wraparound and marking	_____
• Neutral flame adjustment	_____
• Start of cut and torch manipulation	_____
• Pipe rotation	_____
• Final quality of bevel	_____

Basic Skills

Reading

Critical Thinking

Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Oxyacetylene cutting unit with tractor-type torch
- Welding goggles and safety glasses
- Welding gloves
- Sparklighter
- Pliers
- Straightedge
- Soapstone
- Metal as selected by instructor
- Tip wrench, if required

Procedure

❑ 1. Inspect area to make sure it is free and clear of flammable materials and well ventilated, and note location of nearest fire extinguisher.

❑ 2. Select tip according to thickness of metal, place on torch, and tighten with a wrench, according to manufacturer's recommendations.

❑ 3. Place material on work area and set up tractor and torch.

❑ 4. Adjust protractor on torch unit to an angle of 30°.

❑ 5. Determine direction of travel, and determine travel speed according to tip size and thickness of metal, as recommended by manufacturer.

- ❑ 6. Put on cutting gloves and goggles.
- ❑ 7. Light and adjust torch to neutral flame.

  Note: Lighting and adjusting a track-type torch is the same procedure used for a hand-held torch and the same safety rules should be observed.
- ❑ 8. Roll the tractor and torch to a point where the flame is at the edge of the metal, and adjust the flame so that the inner cone is 1/16˝ to 1/8˝ off the metal.
- ❑ 9. Hold the flame at the edge of the metal until the plate turns a reddish-yellow.
- ❑ 10. Open oxygen cutting valve and immediately engage the tractor drive motor.
- ❑ 11. Permit tractor and torch to run the entire length of the cut to complete the bevel.

  Caution: NEVER leave an activated tractor-type machine unattended for even a moment.
- ❑ 12. Close oxygen cutting valve, disengage tractor drive motor, and turn motor off.
- ❑ 13. Turn torch off.
- ❑ 14. Cool the workpiece with water.
- ❑ 15. Inspect bevel for correctness of angle, drag line, and slag accumulation.
- ❑ 16. Have your instructor check your work and continue to practice cutting bevels as directed.

  Caution: When you remove the workpiece for inspection, use pliers.
- ❑ 17. Clean area and check in tools and materials.

Evaluator's Comments: _____

_____

_____

Objective 36

Job Sheet 8—Cut a Pipe Bevel by Hand

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• Pipe positioning	_____
• Use of wraparound and marking	_____
• Neutral flame adjustment	_____
• Start of cut and torch manipulation	_____
• Pipe rotation	_____
• Final quality of bevel	_____

Basic Skills

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Oxyacetylene cutting unit with tip
- Welding goggles and safety glasses
- Welding gloves
- Sparklighter
- Pliers
- Wraparound
- Soapstone marker
- Center punch (optional)
- Pipe with at least 3/16″ wall thickness
- Tip wrench, if required
- File
- Wire brush

Procedure

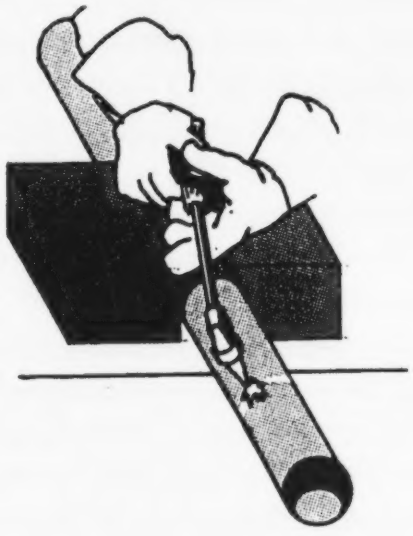
❑ 1. Inspect area to make sure it is free and clear of flammable materials and well ventilated, and note location of nearest fire extinguisher.

❑ 2. Select tip according to wall thickness of pipe, place on torch, and tighten with a wrench, according to manufacturer's recommendations.

❑ 3. Place pipe on a suitable work surface and brace with pieces of fire brick so pipe can be rotated.

❑ 4. Place wraparound over pipe, make sure it overlaps to give a straight line, then mark the cutting line with soapstone.

Figure 1



❑ 5. Put on welding gloves and goggles.

❑ 6. Light and adjust torch to neutral flame.

❑ 7. Start preheating on the sidewall of the pipe at a point slightly down from the top of the pipe, about 10 or 11 o'clock.

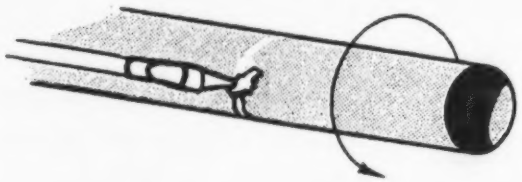
❑ 8. Angle the tip of the torch at the starting point so that it will make a cut of 35° through the pipe wall.

❑ 9. Move the torch down until the inner cone is about 1/16″ to 1/8″ from the pipe surface and heat a spot about the size of a dime until it turns a reddish-yellow.

❑ 10. After the metal turns a reddish-yellow, raise the inner cone to approximately 1/2″.

❑ 11. Depress the oxygen cutting lever slowly, return to proper inner cone distance, cut for a few inches uphill, and then stop and rotate the pipe to the left.

Figure 2



❑ 12. Restart the cut by preheating as required, and keep making short cuts to the left while rotating the pipe until the cut is complete.

❑ 13. Turn torch off.

❑ 14. Cool pipe with water.

❑ 15. Use file to clean slag from inside the pipe and rough edges from the bevel, then clean with a wire brush.

❑ 16. Have your instructor check your work.

❑ 17. Continue cutting other bevels as directed by your instructor.

❑ 18. Shut down equipment, check in tools and materials, and clean area.

Evaluator's Comments: _____

_____

_____

Objective 37

Job Sheet 9—Set Up and Bevel a Pipe With a Pipe Beveling Machine

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• Pipe safely secured	_____
• Torch and beveling machine preparation	_____
• Neutral flame adjustment	_____
• Pipe beveling machine operation	_____
• Quality of bevel cut	_____

Basic Skills

Reading

Critical Thinking

Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Oxyacetylene cutting equipment
- Standard H&M Pipe Beveling machine or equivalent equipment
- Welding goggles and safety glasses
- Welding gloves
- Spark lighter
- Tip wrench
- Mild steel pipe as selected by instructor
- Jack stands or suitable pipe-holding equipment
- Pliers

Procedure

❑ 1. Inspect area to make sure it if free and clear of flammable materials and well ventilated, and note location of nearest fire extinguisher.

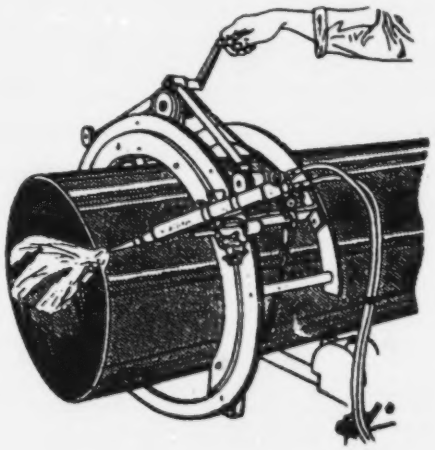
❑ 2. Select cutting tip according to pipe wall thickness, place the tip on the torch, and tighten to manufacturer's specifications.

❑ 3. Place pipe on jack stands and secure it so the beveling machine can be safely installed and operated.

❑ 4. Place the beveling machine on the pipe.

❑ 5. Adjust the boomer assembly by lengthening or shortening the boomer chain until the machine is securely attached to the pipe.

Figure 1



❑ 6. Set the torch to make a 30° bevel by loosening the appropriate wing nuts on the torch holder, and after you position the torch, retighten the wing nuts securely.

❑ 7. Make the appropriate vertical adjustment on the torch holder by loosening the thumbscrew on the torch holder and adjusting the torch tip to approximately 1/4" from the pipe.

❑ 8. Make the appropriate horizontal adjustment by loosening the appropriate wing nut on the torch holder, manually positioning the torch tip to the intended line of cut, and then securely retightening the wing nut.

❑ 9. Put on cutting gloves and goggles.

❑ 10. Turn on the torch fuel valves and light and adjust the torch to a neutral flame.

❑ 11. Eliminate the blow hole when you cut through the pipe by loosening the knurled knob on the right side of the torch holder and tilting the torch up about 3 to 5 degrees from the cut line to allow for preheating and piercing of the pipe.

❑ 12. Heat the pipe until it reaches the proper preheat temperature, and then turn the oxygen cutting valve to the OPEN position to cut through the pipe.

❑ 13. Allow the flame to pierce the pipe, then loosen the knurled knob quickly and return torch to its original position on the intended cut line.

Note: This action will leave the blow hole in the scrap end of the pipe and give you a cleaner cut; you will also get a cleaner cut if you keep preheat to a minimum.

❑ 14. Start the cutting process immediately by rotating the ring gear manually.

❑ 15. Keep turning the ring gear until the beveled cut is finished.

❑ 16. When the cut is finished, turn off the oxygen, then acetylene fuel supplies and remove the beveling machine from the pipe by releasing the boomer assembly.

❑ 17. Inspect bevel for correct angle, drag line, and slag accumulation.

❑ 18. Have your instructor evaluate your beveled pipe.

❑ 19. Shut down and secure equipment.

❑ 20. Check in tools and materials and clean area.

Evaluator's Comments: _____

_____

_____

Objective 29

Job Sheet 1—Braze Weld a Square Groove Butt Joint in the Flat Position

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Workpiece preparation	_____
• Equipment setup and safety	_____
• Flame adjustment	_____
• Proper use of flux	_____
• Filler rod and torch manipulation	_____
• Quality of final bead	_____

Basic Skills

Reading

Critical Thinking

Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Oxyacetylene welding unit with brazing tip
- Welding goggles, safety glasses, and face shield
- Welding gloves
- Portable grinder
- Vise
- Pliers
- Steel plate as selected by instructor
- Bronze filler rod as selected by instructor
- Flux or flux-coated filler rod as selected by instructor
- Firebrick worktable
- Chipping hammer and wire brush

Procedure

❑ 1. Check work area to assure that it is free of flammable materials and properly ventilated; note the location of the nearest fire extinguisher.

❑ 2. Place selected metal in vice and grind surface to remove oxides.

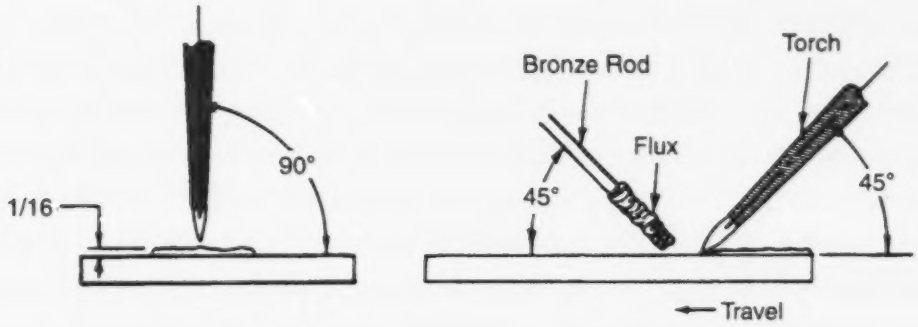
> Caution: Always wear safety glasses and face shield when grinding.

❑ 3. Position metal flat on the firebrick worktable.

❑ 4. Select recommended brazing tip and put it on the torch finger tight.

- ❑ 5. Set up equipment and light torch according to safety procedures previously outlined.
- ❑ 6. Adjust to a neutral or slightly reducing flame.
- ❑ 7. Place rod so that half of it extends over worktable; hold the free end, then melt the rod in half to make it easier to handle and safer to work with.
- ❑ 8. Heat rod slightly and dip in flux, if required.
- ❑ 9. Hold the torch at approximately a 90° work angle and a 45° travel angle, and move it down until flame is about 1/8" from the surface of the metal.

Figure 1



Front View Side View

- ❑ 10. Heat an area of the base metal about 1/2" in diameter with a slightly circular torch motion until the metal is dull red.
- ❑ 11. Immediately after the metal turns dull red, insert the end of the rod into the area where the cone of the flame meets the plate.
- ❑ 12. Allow a drop of molten bronze to form the beginning of the bead.
- ❑ 13. Withdraw rod a short distance, move the flame forward in a slight circular motion, then reinsert the rod to allow more molten bronze to drop on the plate.
- ❑ 14. Check the rod frequently to make sure it has flux on it; when the flux is gone, remove the rod and withdraw the flame slightly from the metal as you quickly dip the rod in the flux.
- ❑ 15. Move flame back onto the metal and continue the procedure until the bead is completed.

❑ 16. Stop just as you reach the end of the metal so molten bronze will not drip off the workpiece.

❑ 17. Shut torch off.

❑ 18. Inspect bead for consistent width, proper height, and uniform flow and adhesion to the base metal.

Note: When too much flux gets on the bead, it may require cleaning before inspection.

❑ 19. Repeat the previous procedure until several parallel beads have been made across the sheet metal, and be sure to stop and clean and inspect as each bead is completed.

❑ 20. Have your instructor check your work.

❑ 21. Clean up area and check in tools and materials, or prepare for next job sheet as directed by your instructor.

Evaluator's Comments: _____

_____

_____

Objective 30

Job Sheet 2—Braze Weld a Square Groove Butt Joint in the Flat Position

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Workpiece preparation	_____
• Equipment setup and safety	_____
• Flame adjustment	_____
• Proper use of flux	_____
• Filler rod and torch manipulation	_____
• Quality of final bead	_____

Basic Skills

Reading

Critical Thinking

Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Oxyacetylene welding unit with brazing tip
- Welding goggles, safety glasses, and face shield
- Welding gloves
- Portable grinder
- Vise
- Pliers
- Steel plate as selected by instructor
- Bronze filler rod as selected by instructor
- Flux or flux-coated filler rod
- Firebrick worktable
- Chipping hammer and wire brush

Procedure

❑ 1. Check work area to assure that it is free of flammable materials and properly ventilated; not the location of the nearest fire extinguisher.

❑ 2. Place selected metal in vice and grind surface to remove oxides.

Caution: Always wear safety glasses and face shield when grinding.

❑ 3. Position the workpieces flat on the firebrick and align them about 1/16″ apart for a butt joint.

Note: Do not lay the pieces of metal flat on the firebrick; place other pieces of metal or firebricks under them so there will be a space between the workpieces and the worktable.

❑ 4. Select recommended brazing tip and put it on the torch finger tight.

❑ 5. Set up equipment and light torch according to safety procedures previously outlined.

❑ 6. Adjust to a neutral or slightly reducing flame.

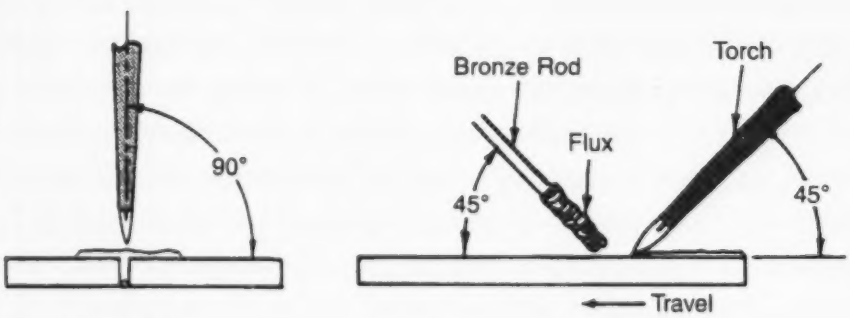
❑ 7. Place rod so that half if it extends over worktable; hold the free end, then melt the rod in half to make it easier to handle and safer to work with.

❑ 8. Heat rod slightly and dip in flux, if required.

❑ 9. Tack each end of the joint.

❑ 10. Hold the torch at approximately a 90° work angle and a 45° travel angle and move down until the flame is about 1/8″ from the surface of the metal.

Figure 1



Front View Side View

❑ 11. Heat about 1/8″ of each edge of the joint with a slight circular motion of the torch until the edges are dull red.

❑ 12. Position the flame in the center of the joint as you insert the rod into the cone of the flame.

❑ 13. Allow a drop of molten bronze to fill the joint.

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- ❑ 14. Withdraw rod a short distance, move the flame forward in a slight circular motion, then reinsert the rod to allow more molten bronze to enter the joint.
- ❑ 15. Check the rock frequently to make sure it has flux on it; when the flux is gone, remove the rod and withdraw the flame slightly from the joint as you quickly dip the rod in the flux.
- ❑ 16. Move flame back into the center of the joint and continue the procedure until the joint is completely brazed.
- ❑ 17. Stop just as you cover the tack weld so molten bronze will not drip off the end of the joint.
- ❑ 18. Shut torch off.
- ❑ 19. Inspect face of bead for consistent width, proper height, and uniform flow and adhesion to the base metal.
- ❑ 20. Inspect reverse side of joint for penetration.

> Caution: Never pick up a piece of hot metal even when you're wearing leather gloves; always handle hot metal with a pair of pliers.

- ❑ 21. Have your instructor check your work.
- ❑ 22. Clean up area and check in tools and materials, or prepare for next job sheet as directed by your instructor.

Evaluator's Comments: _____

_____

_____

Objective 31

Job Sheet 3—Braze Weld a Lap Joint in the Horizontal Position

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Workpiece preparation	_____
• Equipment setup and safety	_____
• Flame adjustment	_____
• Proper use of flux	_____
• Filler rod and torch manipulation	_____
• Quality of final bead	_____

Basic Skills

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Oxyacetylene welding unit with brazing tip
- Welding goggles, safety glasses, and face shield
- Welding gloves
- Portable grinder
- Vise
- Pliers
- Steel plate as selected by instructor
- Bronze filler rod as selected by instructor
- Flux or flux-coated filler rod
- Firebrick worktable
- Chipping hammer and wire brush

Procedure

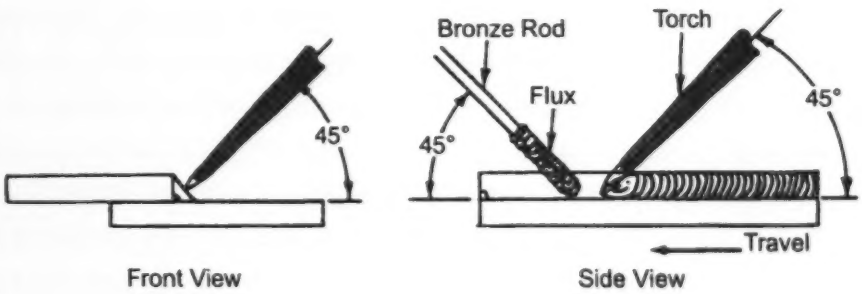
❑ 1. Check work area to assure that it is free of flammable materials and properly ventilated; not the location of the nearest fire extinguisher.

❑ 2. Place selected metal in vice and grind surface to remove oxides.

Caution: Always wear safety glasses and face shield when grinding.

- ❑ 3. Position workpieces on firebrick and align them to make a lap joint.
- ❑ 4. Select recommended brazing tip and put it on the torch finger tight.
- ❑ 5. Set up equipment and light torch according to safety procedures previously outlined.
- ❑ 6. Adjust to a neutral or slightly reducing flame.
- ❑ 7. Place rod so that half if it extends over worktable; hold the free end, then melt the rod in half to make it easier to handle and safer to work with.
- ❑ 8. Heat rod slightly and dip in flux, if required.
- ❑ 9. Tack both corners of each side of the joint.
- ❑ 10. Hold the torch at approximately a 45° work angle and at a 45° travel angle and move down until the flame is about 1/8" from the surface of the metal at the very corner of the joint.

Figure 1



- ❑ 11. Concentrate heat on the edge of the bottom plate first, then with a slightly circular motion, move the flame up and heat the bottom plate until both plates are dull red.
- ❑ 12. Position the flame in the center of the joint, then insert the rod into the cone of the flame.
- ❑ 13. Allow a drop of molten bronze to fill the joint.
- ❑ 14. Withdraw rod a short distance, move the flame forward in a slight circular motion, then reinstate the rod to allow more molten bronze to enter the joint.

- ❑ 15. Check the rod frequently to make sure it has flux on it; when the flux is gone, remove the rod and withdraw the flame slightly from the joint as you quickly dip the rod in the flux.
- ❑ 16. Move the flame back into the center of joint and continue the procedure until the joint is completely brazed.
- ❑ 17. Stop just as you cover the tack weld so molten bronze will not drip off the end of the joint.
- ❑ 18. Shut torch off.
- ❑ 19. Inspect bead for proper leg lengths, correct width and height, and uniform flow and adhesion to the base metal.
- ❑ 20. Turn metal over with the pliers and clean oxidation from other side.
- ❑ 21. Relight torch, adjust to a neutral or slightly reducing flame, and repeat the procedure on the other side of the joint.
- ❑ 22. Shut torch off.
- ❑ 23. Clean and inspect.
- ❑ 24. Have your instructor check your work.
- ❑ 25. Clean up area and check in tools and materials, or prepare for next job sheet as directed by your instructor.

Evaluator's Comments: _____

_____

_____

Objective 32

Job Sheet 4—Repair a Worn Tool with Hardfacing

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Workpiece preparation	_____
• Equipment setup and safety	_____
• Flame adjustment	_____
• Proper use of flux	_____
• Filler rod and torch manipulation	_____
• Quality of final bead	_____

Basic Skills

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Oxyacetylene welding unit with brazing tip
- Welding goggles, safety glasses, and face shield
- Welding gloves
- Portable grinder
- Vise
- Pliers
- Worn plow share or other worn equipment as selected by instructor
- Hardfacing rod as selected by instructor
- Flux as required
- Firebrick worktable
- Wire brush

Procedure

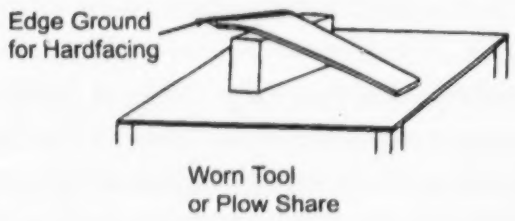
❑ 1. Check work area to assure that it is free of flammable materials and properly ventilated; not the location of the nearest fire extinguisher.

❑ 2. Secure the worn tool in a vise and grind approximately 1″ along the edge until the metal is bright

> Caution: Always wear safety glasses and face shield when grinding.

❑ 3. Place the tool with one over a firebrick on the worktable so that the tool is inclined 20° to 30°.

Figure 1



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❑ 4. Select a recommended hardfacing tip and put it on the torch finger tight.

❑ 5. Set up equipment and light torch according to safety procedures previously outlined.

❑ 6. Adjust to a neutral or slightly reducing flame.

❑ 7. Preheat the total length of the edge to be hardfaced.

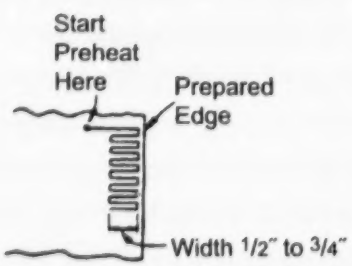
❑ 8. Adjust to a carburizing flame.

❑ 9. Move the flame down until it is about 1/8" above the surface of the workpiece.

❑ 10. Hold the flame still until the edge surface of the tool begins to sweat and displays a glazed appearance.

❑ 11. Withdraw the flame enough so that the end of the rod can be brought between the inner core and the hot base metal so that the tip of the cone just about touches the rod and the rod touches the sweating surface.

Figure 2



- ❑ 12. Weave the torch slightly and allow a drop or two of molten alloy to drop onto the metal surface; make sure the molten alloy spreads out evenly over the area to be hardfaced.

  Note: If the molten alloy does not flow easily and spread out uniformly, it usually indicates the base metal needs more preheating.

- ❑ 13. Withdraw rod from the flame, and spread the alloy further by directing part of the flame onto the puddle and part of the flame onto the surrounding base metal.

- ❑ 14. Put the rod into the flame again with its end touching the forward side of the puddle, and melt more allow into the puddle.

- ❑ 15. Move the puddle with flame motion and alternately reinsert the rod to deposit more alloy until the surface is covered.

- ❑ 16. Shut torch off.

- ❑ 17. Inspect hardfacing to make sure there is good adherence between the alloy and the base metal.

- ❑ 18. Have your instructor check your work.

- ❑ 19. Clean up area and check in tools and materials.

  Note: Your instructor may instruct you to repeat this job sheet using another selected worn tool because the procedure can be readily adapted to hardface plow moldboards, landside plates, grain discs, cultivator sweeps, chisels, and spikes and other types of running or cutting equipment.

Evaluator's Comments: _____

_____

_____

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